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NEW ZEALAND—ITS OCCUPATION AND DEFENCE AGAINST NATIVE AGGRESSION.*

The importance of New Zealand as a field for emigration, especially adapted by its climate and temperature for the Anglo-Saxon race, is fully demonstrated by the rapid increase of its European population.

Notwithstanding its distance from England, entailing a long and expensive voyage, its white population has increased 270 per cent. during the last 10 years; and as a consequence, under the inscrutable laws of God, the Maori race has decreased, if not at the same, at a very nearly similar, ratio.

The following Table, the accuracy of which cannot be questioned, as it has been extracted from the public records, laid before the Houses of Assembly, will give some idea of the attraction caused by the richness of the gold-fields daily being brought to light in both islands.

In 1858 the province of Otago numbered but 6,944 souls, in 1861 the population had risen 317 per cent., and numbered 28,983 souls.

The province of Canterbury had doubled its population in the same period; and although Auckland received a very considerable increase to its numbers, the rapid strides of the south far outstripped the northern capital, and gave the preponderance to the south, a preponderance only to be duly appreciated, in a country where the suffrage is almost universal, the Government responsible, and dependent for "ways and means" on the Houses of Assembly.

Numerical Increase of Population.

Year.	Males.	Females.	Total.
1851.	15,035	11,672	26,707
1858.	33,585	25,669	59,254
1861.	61,008	37,907	98,915

The census was taken during the month of December in each year, excludes the military and their families, who number 6,273 males, 1,021 females; also excludes 1,128 half-castes, and 3,000 miners who

* This paper was contributed by Colonel H. J. Warre, C.B., commanding 57th Regiment in New Zealand, and read in the Theatre of the Institution by Major-General the Honourable J. Lindsay, M.P., on Friday, January 30th, 1863.—Ed.

were in tents in the province of Otago, and whose places of residence could not therefore be defined.

So rapid had been the increase in the southern provinces, that Otago in 1861 exceeded by 3,456 souls the population of the entire colony of New Zealand in 1851.

Before proceeding to investigate the claims of the several provinces to military protection, it will be necessary to ascertain the distribution of the native or Maori population, which has been variously estimated, it being impossible to vouch for the accuracy of any census, taken at different periods during the twelve months ending 1858, and professing to give only an approximate estimate of their numbers, viz.:—

In 1841 *the native population of both islands was estimated at* 104,000 *souls.* In 1858 their number was as follows:—

	Males.	Females.	Total.
Auckland.....	21,630	16,560	38,190
Taranaki	1,751	1,264	3,015
Wellington	4,559	3,540	8,099
Hawke's Bay.....	2,044	1,629	3,673
Total North Island.....			52,977
Nelson.....	692	428	1,120
Canterbury	349	289	638
Otago	285	240	525
Total Middle Island			2,283
Stewart's Island.....	110	90	200
Grand Total			55,467

The decline of the native race is very extraordinary and very rapid. 15 per cent. may be deducted from the above number for the decrease during the last 5 years. (The above census having been chiefly made in 1857.) This will give as the present population of the north island about 45,000, of the middle island about 1,900.*

The Secretary of State for the Colonies, in a despatch† dated 26th May, 1862, addressed to Governor Sir G. Grey, K.C.B., states as follows:—

I cannot hold out to you any hopes that a large military force will, for any length of time, be kept in New Zealand. It is for the colonists themselves to provide such a military police force as will protect their out-settlers. If it is not worth while to

* The population—European and Native—of the South or Stewart's Island is so insignificant it is never taken into account. The Middle Island is so frequently termed the South Island, in contradistinction to the North, that the word "South" must be understood to apply to the *Centre* Island of the New Zealand group.—H. J. W.

† See Papers laid before Houses of Assembly, printed and published by authority.—H. J. W.

the colony to furnish such protection, it would seem to follow that it is not worth while to retain these out-settlements.

Although the term "out-settlers" in such a country is not clearly defined, all settlers not living under the protection of the great centres of population may be so classed.

The following Tables will show pretty nearly the number of persons living under the protection of the garrisons, occupying the great centres, or chief towns, in each province, in the north island, viz.:—

	Males.	Females.	Total.
Auckland (including Onehunga and the Pensioner Settlements)	8,151	7,317	15,468
New Plymouth	1,062	842	1,904
Wanganui	1,065	895	1,960
Wellington	2,052	2,124	4,176
Napier	533	391	924
Total			24,432

and the number of inhabitants scattered over the several districts, viz.:—

	Males.	Females.	Total.
North of Auckland—			
Monganui	293	194	487
Bay of Islands	582	387	969
Marsden	926	727	1,653
Total			3,109
South of Auckland—			
Franklin	1,684	1,122	2,806
Raglan	1,585	1,138	2,723
Taranaki	72	33	105
Ramgatiki	491	404	892
Porirua	998	881	1,879
Hutt Valley	1,014	952	1,966
Wairarapa	1,006	687	1,693
Clive	782	352	1,134
Total			13,198

The number of natives in the middle island is so insignificant, and they are so much under control, that it is not necessary to ascertain the exact districts in which about* 60,000 Europeans reside upon that island.

* Nelson	9,952
Marlborough	2,299
Canterbury	16,040
Otago	27,163
Southland	1,820
	57,574
Miners (not included in above estimate)	3,000

Except upon Cook's Straits they are safe from native attack, but such is the condition of the natives in the northern island, that on the 19th December, 1861, His Excellency Sir G. Grey addressed a letter* to Lieutenant-General Cameron, C.B., commanding the forces, stating that—

"The European settlers are afraid to continue their operations, so that the progress of the country is at a complete standstill; while the Government does not dare to move troops to protect other parts of the colony, lest the country near Auckland should be instantly attacked; in fact, we have been and are at present entirely at the mercy of the natives, and they know it."

His Excellency then directs that the roads (since constructed by the troops during the summer, 1861–62) should be at once commenced, so that "we shall then be enabled to undertake either defensive or aggressive operations against an enemy, as circumstances may require."

To enable the "Queen's subjects† in all parts of these islands to participate in the benefits of 'law and order,' to be maintained in the undisturbed possession of their lands, and to enjoy perfect security of life and property," it is evident that the Maories must submit to be governed by English law.

The late war has proved how futile have been the attempts hitherto made to reduce the Maories to obedience; a different system must be adopted, and such system should be enforced before the large force of regular troops, now at the disposal of the Colonial Government, is withdrawn.

Disposition of the Troops.—Two-thirds of that force is now concentrated in the province of Auckland. It must be more equally distributed in order to make its presence felt, not necessarily to produce collision, but to support the law, and to coerce such native tribes as sullenly oppose the Queen's authority.

A military police should be organised to take the place of the regular troops upon their withdrawal, and military settlements should be established on the borders of the disaffected districts.

Assuming that the regular troops in this colony amount to, say 6,000 men, of whom, viz.:—

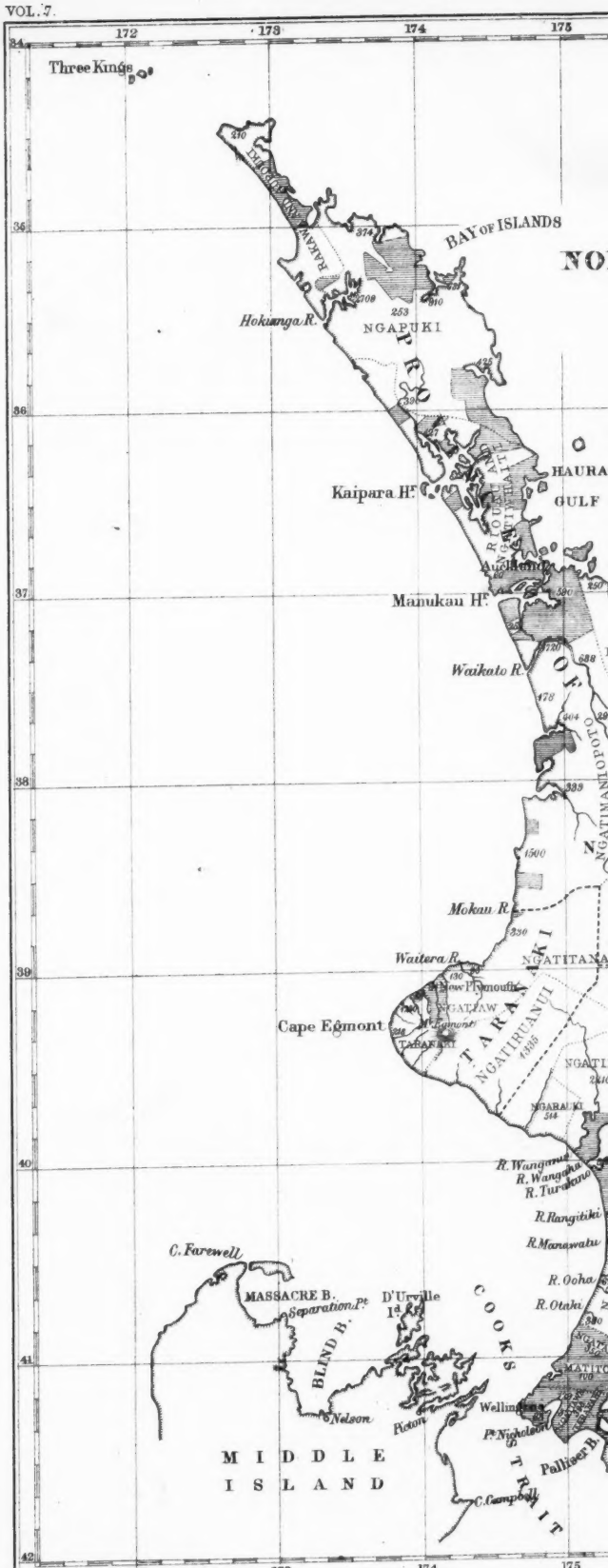
800 are at New Plymouth,
370 are at Wanganui,
350 are at Wellington,
380 are at Napier,

it follows that there are, say 4,000, in the province of Auckland.

Taranaki.—As the province of Taranaki was devastated, and nearly all the houses lying wide of the blockhouses which surround New Plymouth destroyed, the troops at that place are sufficient to occupy the different posts at Waitara, Mahoetahi, Bell Block, and Omata. They might also occupy Tataraimaka, an isolated block of land cleared, and partially cultivated, about 15 miles to the south of New Plymouth,

* See Papers laid before Houses of Assembly.—H. J. W.

† See Sir G. Grey's Minute on his Excellency's system of Native Government.—H. J. W.


172
173
174
175
34
36
37
38
39
40
41
42
Three Kings
BAY OF ISLANDS
NGAPUKI
Hokianga R.
Kaipara H.
Manukau H.
Waikato R.
Mokau R.
Waitara R.
New Plymouth
Mt Egmont
Cape Egmont
TARANAKI
NGATITAWA
NGATIRUANUI
NGARAUKI
R. Wanganui
R. Wangaehu
R. Turakina
R. Rangitiki
R. Manawatu
R. Ohau
R. Otaki
C. Farewell
MASSACRE B.
Separation Pt
D'Urville I.
BLIND B.
COOK'S STRAIT
Nelson
Picton
Wellington
Pt Nicholson
Palliser B.
C. Campbell
MIDDLE ISLAND

Map of the
NORTH ISLAND, NEWZEALAND,
Shewing the
NATIVE AND EUROPEAN TERRITORY.

G.C. Adams, Fecit.

The European portion of the Island is shewn thus ..
The remainder of the Island is Native Territory.

The figures indicate the numbers of the Maoris in each Locality.

J.R. Jobbins

through which all natives proceeding by the coast to and from Wanganui must pass. The other garrisons at Napier, Wellington, and Wanganui, should be reinforced to enable "flying columns," as hereafter described, to be formed to shut in or blockade the hostile districts.

Flying Columns.—Each column should be composed of from 300 to 500 men (one-fifth of whom should be mounted) according to the population in the native districts they are required to hold in check.

It must be borne in mind that the natives are divided into numerous* small tribes or *hapus*, residing in their own districts, chiefly on the sea coast; that they cannot assemble together in large numbers on account of the difficulty in obtaining food, and that their chiefs no longer possess the power of controlling several tribes for the purposes of war, or of combining them for good or evil.

If the European settlers are to maintain the undisturbed possession of their lands, the native race must be brought into subjection.

If the natives are not subjugated, they will be exterminated.

To save them from such a fate, to teach them to submit to the benign laws of a civilised country, the following "project" is submitted, in the hope of preserving for future good, a noble, brave, and self-reliant people.

Adaptation of Regular Troops to service in New Zealand.—In a country like New Zealand, where roads do not exist, or are but imperfectly formed beyond the limits of European settlements, the ordinary service of "*the three arms*" must be adapted to the guerilla nature of the service.

The European settlements must be protected, and every precaution taken to prevent the destruction of "homesteads" lying wide of the centres of population.

To effect these objects the presence of the troops must be *felt* throughout the island, and more especially in the disturbed or disaffected districts, and at the same time they must be prepared to meet and compete with an almost invisible enemy, able to traverse the country in every direction.

Large masses of troops are not required to effect these objects, on the contrary, they are impeded by the necessary amount of provisions, ammunition, and baggage requiring to be protected.

"*Flying columns,*" consisting of not more than "500" men of all arms, would appear better adapted for such purposes; and each column properly organised, well armed, well supplied, and well led, would be able to compete with any number of natives that could be collected and kept together in any district.

Every column thus organised must be complete in itself, and although acting to a certain extent in concert with the troops in the nearest garrison from whence it would draw its supplies, it should be independent of all exterior aid.

By such an actual demonstration of force throughout the country, by proclaiming certain districts, and maintaining as strict a blockade

* See map.—Pl. xvi.

of such districts as the nature of the country will admit; by cutting off all articles of European luxuries to which the natives have now become accustomed, and by prompt and effectual punishment of any tribe or individual native attempting to evade the restrictions under which the proclaimed district is placed, it is believed that the native tribes would speedily find it to their advantage to submit to British rule—to accept the machinery by which Sir G. Grey's admirable system is to be established, and to acknowledge the Queen's supremacy.

Such pressure, quietly but firmly enforced, need not necessarily lead to actual collision, but would secure, not "a temporary and precarious," but "a well-grounded and lasting peace."—(See Despatch, Duke of Newcastle, 5th June, 1861.)

Districts: Thames 300, *Drury* 500, *Raglan* 300 (*Auckland*); *Hawke* 500, *Taranaki* 300, *Wanganui* 300.—To make the *flying columns* more effective, they should be so located as to afford, if not actual, moral support to one another, and it would be very desirable to increase the number of these columns by supplying the place of the regular troops in garrison with militia or volunteers; this might become necessary in times of actual disturbance, but for present purposes it is presumed that six columns, as noted, would act with great effect: the three first on Waikato, and the two last named on the tribes between New Plymouth and Wanganui. Columns so placed would derive great support from the garrisons in the several districts in which they are serving, and from whence they would draw their supplies of provision and ammunition. Under all circumstances every endeavour should be made to keep open their communication with the sea coast, and certain points should be pre-arranged where small steamers could land supplies at stated times.

Military Police and Settlers.—From the regular troops so employed it is proposed to select certain men, to be located at certain points, where their presence would act as a material guarantee for future peace.

To make this force effective, it will be necessary to obtain the sanction of the Imperial Government for every good soldier over five or seven years' service (limited service men), and over twelve or fourteen years (unlimited service men), to be allowed to take their discharge, with a view of forming a local corps, in which they should be bound to serve under the Articles of War and Mutiny Act (Militia), for three or five years, as may be required. At the end of this period, in addition to the increased rate of pay which, for such time, it would be good policy to offer, to secure good and willing men, a scale of *grants of land* should be arranged, to be given to soldiers so employed, according to rank and conduct; this scale should be made liberally, to give this class of settlers from whom the future police of the country is to be drawn, an advantage over the ordinary immigrant.

The Romans so fully recognised the principle that "Want often wastes an army more than battle," and "famine is more terrible than the sword," that they made it a point of supreme importance to ensure a plentiful supply of provisions for their men.

Forage and Corn for their Horses.—This is the more necessary to be

attended to in New Zealand, which is absolutely destitute of any animal life, to supply the necessities of even ordinary travellers, and affords so little food for horses or cattle, that both have been known to starve from absolute inanition, when lost in the Bush.

Under circumstances very similar to those which now occupy our attention, the Romans took fifty years to conquer England; they did so in the end, by opening out the country, forming roads through dense bush, across arid plains and unwholesome marshes; they paid the greatest attention to the selection of the sites of their great encampments, which to this day show the admirable judgment displayed by the "prefects" in their selection of situations both for health and defence. The climate of England is much rougher than that of New Zealand, nevertheless military exercises were attended to at all seasons of the year, and they considered that such exercises were more effectual in preserving the health of their soldiers than medicine. The camps were frequently changed, and all the sanitary precautions of the most perfect military hygiene were exercised to the fullest extent. Such should be our course in New Zealand. No mistaken economy should crowd men into low wooden huts, which at night draw up the steam from the saturated ground, obliging the inmates to live in a perpetual steam-bath.

No pains should be spared to supply our soldiers with good food, good warm clothing in winter, good light flannel clothing in summer (the nights in New Zealand are always cold), remembering that "constant and well appointed preparation for war is necessary to preserve peace."

The officers commanding these flying columns, like the prefects of old, must therefore be most carefully selected; and whilst permitted to retain the command, must be supported by Government, under all ordinary circumstances, to enable them to act with vigour and without fear of rebuke.

If they exceed their duty, or act contrary to their instructions, let them be at once replaced; but so long as an officer is in command of such an independent force, he should be left to the free exercise of his judgment in all matters affecting the well-being and discipline of the soldiers under his orders.

Rations abundant elsewhere are not sufficient in a country where nothing can be shot, and nothing can be bought. It should be the special duty of the officer commanding to see that that his men are well and liberally supplied. He should have the power of giving them an extra ration when occasion demands such an indulgence, and above all things he should be most careful that his men are not unnecessarily harassed or disturbed, especially at night. When in the field the rations should be increased in quantity, and every endeavour made, not only constantly to exercise the men in all military gymnastics, to keep them equal to any emergency, but to excite emulation on a service which in itself offers nothing to tempt the cupidity, or excite the zeal of a soldier.

The condition of the sick and wounded should be ameliorated by every possible means, and all "casuals" sent by every avail-

able opportunity, to the head-quarters of their corps, or to Auckland.

In such a country as New Zealand, which, as Algeria was to the French, is the real practice-ground for training skirmishers, every care should be taken to teach the soldier to avail himself of every trifling inequality of the ground. General Yussuf, in his admirable little work "De la Guerre en Afrique," asserts most truly that ground seldom presents a sufficiently level surface for even 600 yards to permit cannon or the rifle to fire effectively—small obstacles, and the natural inequalities conceal not only a single man but small bodies of troops. The recent campaign in Italy, where the per centage of loss was barely half that which occurred from the old smooth bore in the wars of the empire, show us but too plainly that the battle field is the only practice ground upon which we should calculate the performance of the rifle. How much more necessary is it, then, that the soldier should be trained to reserve his fire, where every flax-bush and every gully may conceal an enemy.

The description the Duc d'Aumale gives of a camp in Algeria, where the wily Kabyle was not superior as an enemy to the crafty Maori, should apply to New Zealand, viz. :—"You see no Videttes, but wait till the officer goes his rounds, a watchful Zouave is lying flat on the ground below the brow of the hill. Behind yonder clump of bushes you will find a few couple of Zouaves. Should an Arab creep up to these bushes to see what is going on in camp, a Zouave will not fire, but despatch him quietly with the bayonet, so that the camp may not be unnecessarily alarmed," &c. How can we expect soldiers, whose only idea of such duties is learnt on the smooth parade-ground of some peaceful garrison, to know such a mode of warfare, but they can be taught, and the north-west frontier of India has shown how readily.

Before an enemy a soldier is useless who cannot be trusted on outpost duties, standing or sitting; under such circumstances, every ruse or stratagem should be encouraged, not only to save your own men, but to destroy your enemy, who will otherwise undoubtedly destroy you.

Water.—When in the field, to guard against the deleterious effects of *river* and *swamp-water*, it should be boiled before being used, and this will be found a simple but effective remedy against diarrhœa and looseness.

Canteen.—Many soldiers happily now no longer require *liquor* as a necessary stimulant, but there are many excellent men to whom long habit has made liquor an absolute necessity. No liquor should be issued as part of the daily ration, but each column might be supplied by a canteen, where liquor might be purchased under certain restrictions. A well-regulated canteen not only supplies many necessaries of life, but it keeps men within the limits of the camp.

Officer Commanding.—The duties which devolve on an officer commanding are too well known to require further detail. He should report to head quarters by every available opportunity, whether on matters of importance or not; it is often as necessary to know that

a detached body of troops* are "all right" on a certain day, as it is to know that they have chastised an enemy. He must maintain the strictest discipline consistent with the nature of the service.

Staff: Field-Adjutant, Sergeant-Major, Provost-Sergeant. Quartermaster, Quartermaster-Sergeant, Pioneer-Corporal.—His staff should be well selected. A good field-adjutant, with such a force, is as valuable almost as a good commandant; and his quartermaster should thoroughly understand his duties, and report daily the amount of provisions on hand. Good assistants to these officers would render a larger staff unnecessary, as it should be the special duty of the commanding officer not only to give his orders, but to see that they are implicitly obeyed.

Artillery and Ordnance, &c.—When the late Maréchal Bugeaud was first appointed to a brigade command in Algeria, he found the French afraid to move out of their entrenchments without artillery. In spite of the earnest representations of other officers—some of them superior in rank to himself—who maintained the theory adapted to civilized war, of the moral support given to troops by the presence of artillery, he discontinued its use, and encountering Abd-el-Kader at Sikkak, gained a complete victory over the Emir, whose savage hordes could not cope with the *discipline* of troops able to move with rapidity off the ordinary tracks. The successes of the French in Algeria dated from this action, and the only artillery attached to the "*flying columns*," which were afterwards extensively organized, was the "mountain howitzer," which could be readily carried on a camel's back, or slung between two mules or horses.

Such a system should be adopted in New Zealand, or artillery might be dispensed with altogether, unless upon certain occasions, as a battering train against the enemy's "pah."

No mountain-guns can compete with the range of the "Enfield Rifle," and the rapidity of movement gained by their absence fully compensates for their loss.

During the siege of Olivenca, in 1811, the French mounted field-guns on ordinary bullock-cars, strengthened by a framework and block under the pole, and they used them with considerable effect.

For transport, to save the gun-carriages, which are often much damaged by jolting over bad roads, such carriages might be made use of in this country with very excellent effect.

Three-pound Armstrong Guns, Howitzers, Cohorns, Rockets.—For all ordinary purposes very "light field-guns," or "mountain howitzers," "cohorn mortars," and "rocket carriages," all of which can be carried on a horse, or slung between two animals, are all that are necessary to search the bush-covered ravines, drive the enemy from any temporary cover, and batter down the stockade of any anciently constructed pah.

Any such position not readily reduced by a *coup-de-main*—having blown in the stockade with a bag of powder—might be left to its own

* See Life of the Duke of Wellington when General Crauford was in command of the Light Division, at Torres Vedras.—H. J. W.

solitude, or to the old women and children who might possibly be left to garrison it, if troops were moving about the country. "Hand-grenades" should be extensively used when practicable, as also "fougasses," permanent for permanent camps, or portable for temporary purposes.

"Spring guns," to protect the approaches to a camp, or bivouac, and save sentries. "Old musket-barrels," fastened on to a board with a wire (attached to a fuse or the trigger) drawn across a path, or likely means of approach, give the alarm, and prevent sentries being cut off.

Rifle-pits and small detached works should be thrown up to protect exposed sentries, and "dummies" may frequently be placed to advantage in very exposed positions where sentries are liable to be cut off.

Vertical fire is always preferable to *horizontal*. Heavier guns might be necessary to reduce strong pahs, but it is wonderful how little effect round shot have against a stockade, which a bag of powder, containing from 30 to 50lbs., would level with the ground, and afford a practicable breach.

If heavy guns are therefore required, they should move under their own escort, and not hamper the movements of the column.

Wooden lines of rails or "tramways," say 12 feet long, should be carried with each gun or waggon, to facilitate its passage across swamps or over boggy places.

Cavalry.—Mounted men, well horsed and good horsemen, are all-important to co-operate with infantry, whether as videttes, patrols, escort for reconnoitering parties, or bearers of orders or letters from one post or detachment to another.

More danger is to be apprehended from small bodies of natives acting independently, than from any larger force under any one chief.

Young active men, therefore, accustomed to the country, and to their horses, would be invaluable to keep such small parties of natives at a distance from the camp, and to cover the advance of, or rear of, the column.

They should be armed with a "revolver," "pistol" or "carbine," or with "pistol carbine," which makes very good practice at 200 to 250 yards, and sword; the pistol or carbine should be carried on the person, and not in the holster. A good strong waist-belt might be fitted for sword-pouch and pistol.

Such mounted men must learn to act independently, be good and dashing horsemen—able to gallop up to a point, jump off, take steady aim, load, and remount without loss of time; they should be trained to carry another man for a short distance on their cruppers; such a force, so organised, would make themselves dreaded by the natives, whether single or in small parties, and by their rapidity of movement, prove more formidable than three times their number of infantry.

No pains should be spared to make such a force efficient, not as trained cavalry soldiers, but as good dashing horsemen, able and willing to go where ordered, and do what they are required.

Instead of holsters, a pair of large wallets, a cloak or blanket rolled at the back of the saddle, a pair of fore-shoes with nails, a nosebag

for corn, and a stout blanket folded carefully under the saddle, to save the horse's back and afford cover at night, would complete the equipment of as perfect an irregular cavalry soldier as this country requires.

This mounted corps must be organised by volunteers from the settlers under 30 years of age.

Infantry.—So long as these columns are composed of regular troops, but little alteration can be made in their equipment, which, however, may be very effectually *lightened* by substituting a haversack, or waterproof bag, for the knapsack, in which to carry a pair of boots, and dry flannel shirt and socks, &c.

Instead of the scarlet tunic, the great coat cut off just above the bend of the knee, the flaps of which can be looped back, when not required to protect the legs against rain, will be found a most excellent substitute for uniform, as it combines coat and great coat, is invisible at a certain distance, and is easily replaced.

The ordinary regimental trousers and gaiters will answer as well as any other kind of leg dress.

The Enfield rifle is as good an arm as can be placed in the hands of a soldier—too good for many—but every man should be perfected in its use, and be taught to take care of his ammunition. A soldier so armed is more than a match for any number of Maories, if he would only learn to *reserve his fire.* So long as the rifle is loaded, no Maori would approach even a single man; once unloaded it requires time to reload, and the soldier's advantage is lost—he gets flurried, the bullet probably sticks in the rifle barrel, and the Maori creeps upon him, his knowledge of the ground giving him much the advantage—this is instanced as an extreme case—no soldier should be placed on duty *singly* unless in the camp.

A certain number of men in each company, men who have proved themselves worthy of being so armed, may be armed with the "double-barrelled rifle" or a "revolver pistol" for close quarters; but the greatest care should be taken to prevent the possibility of mistake, by every rifle or revolver being of equal gauge.

In lieu of the knapsack, every man should carry a grey blanket, folded square on his back, and folded within this blanket, a pair of trousers and flannel shirt. Attached to his waist-belt, each man should carry a tin cup and a good sailor's knife.

In addition to the above-mentioned articles, which are personal kit, the following articles of camp equipage and field equipment should be distributed and carried by every company, of say 60 men, viz.:—

4 camp kettles,
4 spades,
4 shovels,
2 pickaxes,
2 crowbars,
2 large American axes,
2 smaller „
8 bill-hooks,
2 coils—10 fathoms $\frac{1}{2}$-inch rope,

30

the above articles should be carried in turn—day about—by men of the company not required as skirmishers—and slung in the same manner as pioneers carry their ordinary tools.

No body of men should ever leave their camp without at least two days' supply of cooked provisions in their haversacks; it is impossible to determine beforehand the duration of any expedition against savages, and this provision will render the party independent, and place them beyond want.

Hospital Ambulance, Transports, &c.—Field-panniers with all necessary implements being now provided for all infantry regiments, it is hoped that the hospital or ambulance can be provided by each regiment according to regulation.

No wheel-carriages should be required, but "*stretchers*" should be provided, and it would be a great relief to wounded or sick men if "cacolets," similar to those used by the French, could be provided and adapted to bullocks.

For field service, a tent for every 20 men, and one for every 3 officers is ample, as one-fourth of the force at least will always be on duty.

Transport.—The provisions, ammunition, and supplies of every kind should be under charge of the Quartermaster, who must also be in charge of the transport corps, picked men from the infantry armed and accoutred like other soldiers, but exclusively employed by the Quartermaster, and forming his guard on the march, &c.

It is impossible to lay down any fixed rule to limit the amount of stores, &c., to be carried on a march. They must be regulated by the officer commanding, who should be most careful to take only so much as will be actually required when on any expedition.

The ammunition should always be kept up to 300 rounds per man.

Survey.—An engineer officer or civil engineer as surveyor should be attached to each column to determine certain points, and sketch in the country through which the column passes.

A few engineers (sappers and miners) would instruct the men in bridging swamps, cutting down scarps, and throwing up necessary field-works; a certain number of men should accompany the advance guard to clear the way, bridge the swamps, and clear dangerous defiles of low underbrush, &c.

The site of a bivouac or camp should be carefully selected, with a view to prevent the possibility of surprise, and an area of a couple of hundred yards cleared of fern, undergrowth, &c.

Pack-horses or Bullocks.—Wheel carriages or carts should be altogether dispensed with, and their place supplied by pack-horses or bullocks.

Draft-bullocks can be trained to carry a pack or panniers in a very few days, but should not be overloaded at first.

Natives.—Attached to each column should be an "*interpreter*," under whom should be a few loyal and trusty natives, selected for their knowledge of the country, and of the habits of the natives.

The *interpreter* should be most carefully chosen, as on him would devolve the punishment of all native offenders; and on him the officer

commanding the column must rely for all information gained from native sources.

If it were possible to train natives, they would become the best light troops in the world; their wonderful sagacity, their knowledge of ground, and of the mode of concealing themselves, their rapidity of movement and power of sustaining fatigue, fit them admirably for light infantry; but their habits are treacherous, and it would require more time than can be now spared to indue in them habits of truth and obedience.

Military Police.—On the withdrawal of the regular troops, it will be necessary to form a "*colonial corps*," or to organize a "*military armed police*," for special service in the colony.

From the regiments* now in the country, a considerable number of men are anxious to obtain their discharge, with a view to settle in the colony.

To enable a greater number to do so, with a view to their enrolment for 3 or 5 years, as may be required, in the "*police*," all limited service men over 5 or 7 years' service, and all unlimited service men over 14 years' service, might be granted a free discharge on condition that men so discharged serve for the period above-stated, and remain subject to the provisions of the (Militia) Mutiny Act and Articles of War, until their services are finally dispensed with by the colony.

This police might be established on the model of the "*Irish constabulary*," the duties would be very similar, and there would be no difficulty in obtaining the printed regulations and adapting them to New Zealand.

Lieutenant-Colonel Pitt Kennedy, in an admirable article on national defensive measures, published in *The Journal of the United Service Institution*, remarks that "the difference between the militia principle "and that of the volunteers is remarkable in many respects." "The "militia soldier must be paid by the State whilst embodied for train-"ing." "The volunteer costs comparatively nothing as a soldier, "because his productive time for earning a livelihood is not interfered "with—his military pastime injures neither his employer nor himself." "On the other hand, unless the volunteer force be *thoroughly organised*, "sufficiently numerous, and rightly distributed, its effect must be "rather *inimical* than advantageous; it would lull the country into "imaginary security."

This axiom applies most especially to New Zealand, where neither the militia nor volunteer force has been properly enrolled or organised; but where a certain number of loyal and gallant men, when threatened by the enemy, volunteered to defend their own homes.

Population.—The male population of the northern island, according to the last census, amounts to 22,956, out of which could be drawn at least 10,000 men between the ages of 16 and 45, during which period they are eligible as militiamen.

Militia.—To protect the different settlements, and to show the

* Each of the four regiments likely soon to be withdrawn, viz., 40th, 57th, 65th, 70th, would give—say 200 volunteers—a respectable number of 800 men from which to select the policemen.—H. J. W.

Maories that the British population are willing and determined to hold their own, even on the withdrawal of the regular troops, it will be necessary to swear in every male inhabitant capable of bearing arms, arrange them according to their several classes, and organise them on a proper footing.

Ten thousand men form a respectable force on which to depend should necessity oblige, but the density of population in reference to area is so variable, that large sections of country partially cleared and inhabited would be devastated before the great centres could be roused to arm themselves, even in their own defence.

Police.—The armed police is intended therefore to supplement the militia, but not altogether to dispense with its enrolment. The militia may be necessary to resist external enemies—the armed police will keep down internal commotion—will give time for the militia to be called out, if required, and will eventually add so many loyal and able-bodied men to the colony.

Such men should be liberally paid, not by a very exorbitant rate of daily pay, but by liberal grants of land when such service is no longer required.

Grants of Land.—To excite emulation and induce good men to serve, a scale should be published showing the amount of land Government is prepared to grant, and in what districts. This scale should include officers, non-commissioned officers, and ordinary policemen. It should also be extended so as to reward men for good conduct or gallant service during the period they remain under the orders of the colonial government.

Settlements.—The European settlements in the north island range chiefly along the sea-coast. They consist generally of one large town or centre of population, which gradually expands up and down the coast to a considerable distance, but, with the exception of Auckland, to a very limited extent inland. The native tribes are located in a very similar manner, filling up the intervals of coast between the European settlements, except on the Waikato river, where a large and powerful tribe, or collection of tribes, are established on and about Lake Taupo. Except on some few navigable rivers, such as the Wanganui, and the chain of lakes leading from the Bay of Plenty inland, the whole of the interior of the island is very sparsely populated, is covered by a dense bush through which even the Maories themselves find it very difficult to penetrate, and is broken and contorted by a series of ridges and furrows radiating from the mountains which run diagonally across the country.

Such a country is utterly impracticable for military operations; no description of troops could carry supplies across the innumerable gullies and swamps by which it is intersected—even the natives seldom attempt to do so, and only in very small bodies. The country is destitute of food for man or horse. Under such circumstances, and with a view to the protection of the European settlements, it would appear desirable to locate the police on the boundaries of the native and European lands, where they would be enabled to keep a proper sur-

veillance over the lawless tribes in their vicinity, and to oppose the passage of any armed body of natives.

North Island.—The north island may be divided into two parts in reference to disaffected tribes, viz., all natives living north of Auckland may be considered loyal, and will remain so, unless some serious reverse occurs to weaken still further the power of British rule. All natives living in the country to the south of Auckland may be considered more or less involved in what is called the *king movement*, are more or less adverse to the Queen's government, and pretend to prohibit the sale of land.

Sir G. Grey's System of Native Government.—It is essential to the working of the system, so ably conceived by the present governor, for the introduction of law and order, that the machinery by which this system is to be worked, shall be accepted and allowed fair trial. Many of the tribes have received the officers appointed for this purpose, but many unhappily obstinately refuse to accept any magistrate, or to abide by any law but their own unruly will. To coerce these tribes, and at the same time to protect the European settlements from their summary vengeance, this police is to be formed, and associated with it under their own officers, specially selected and appointed, should be a proportionate number of *native policemen*, also carefully selected from the friendly tribes.

Result.—The result would soon be apparent, the hostile natives would be afraid to move out of their own districts; they would be unable to obtain European luxuries to which they have become habituated; and they would soon learn to respect the power, without the protection of which they must revert to their former state of barbarism.

Every effort should be made quietly, but steadily, to disarm all natives whether hostile or friendly—the one cannot be disarmed without the other—arms are useless in a country, where there is no game, except for war; and until we deprive half-civilized savages of the means at any moment of asserting their independence, it is hopeless to anticipate "a well grounded and lasting peace."

Expense.—The expense of this system of police will, doubtless, be for a time considerable, but it will diminish every year as the necessity for such a force decreases; while the provinces will be benefited by a large accession of able-bodied settlers, and the revenue of the colony will derive similar benefit from the increased consumption of articles necessary for their existence.

Equipment of the Military Armed Police.—The arms, equipment and costume of the "military" or "armed police," should be adapted to the country—the colour of the uniform should be *grey*, to deceive the keen eyes of the natives.

The "Enfield" rifle is as good an arm as can be placed in the hands of a soldier; and all men are more or less accustomed to its use; the diameter of the bullet should be slightly reduced, to allow of more rapid loading, and to prevent the possibility of the bullet sticking in the barrel, which sometimes happens in rapid firing.

The "short rifle" is easier carried, and quite as effective as the

long—every man should be perfected in the use of his rifle—too much pains cannot be taken to make every man a *good shot*.

One-fifth of the corps should be mounted, and this proportion should be attended to as closely as practicable, at all the out-stations. Every mounted man should be trained to be equally effective on foot. He should learn to be a good horseman, but not to consider himself merely a cavalry soldier.

A certain number of men of each division—men who have proved themselves worthy of being so armed—should be each supplied with a revolver pistol and belt.

The cavalry should also be so armed, in addition to the ordinary cavalry breech-loading carbine (Sharpe's), but the gauge of every arm, rifle, carbine or pistol, should be the same.

Every man should wear the sword-bayonet or bayonet, as at present in use.

Belts should be black or red leather—and a single waist-belt would appear ample for all ordinary purposes—a small pouch should be attached to it to carry twenty rounds; if any further supply is necessary, it should be carried in a small waterproof "shot-bag," or rolled up in the blanket or great coat.

A small waterproof bag, black or red leather, should be substituted for the knapsack, and the kit should be carried in it, and reduced to such articles as are absolutely necessary.

Dress.—A tunic of Melton grey, or any of the different shades of grey so largely manufactured, and now supplied by the Home Government to all rifle corps at a very low cost, a pair of trousers—same or stouter material and colour—a pair of leather gaiters, coming well up the calf of the leg, a forage cap and peak (to which every soldier is accustomed) would complete the costume for parade purposes.

On service, a grey frock should be substituted for the tunic, and worn loose with the belts underneath.

Underclothing should at all seasons be flannel or woollen.

An ordinary infantry great-coat, and a couple of grey blankets—one of which might be dispensed with on the march—would complete the equipment, and enable a man to camp out without a tent for a few nights in succession, at any period of the summer and autumn, in any part of the northern island.

Every man should be provided with two pair of high-low boots to lace up the front.

In lieu of the knapsack, the great-coat and one blanket should be folded square, and carried like a pack on the back; in the blanket a pair of trousers and clean flannel shirt and socks might be carried, or the blanket might be rolled and slung over the left shoulder.

Each man would carry—

1 forage cap and peak,
1 grey tunic or serge frock,
1 pair grey trousers,
1 pair leather gaiters,
1 flannel shirt,
1 pair worsted socks,

1 neck handkerchief,
1 pair boots—lace-up,
1 great coat—folded square,
1 grey blanket ditto,
1 leather bag or haversack,
1 tin drinking cup,
1 sailor's knife,
1 rifle and bayonet complete,
1 waist-belt, with small pouch,

on his person, in addition to which, but entirely for service in quarters, he might be supplied with an additional article of each kind for his personal use, as also with another grey blanket, and leather bag in which to keep his spare kit.

Officers and non-commissioned officers should carry "field glasses."

The number of men to be employed in this force is limited by act of assembly to 500.

Such a number of men divided among the several provinces would nullify the effect of the force so long as its services are necessary to suppress latent insurrection.

Assuming that its services are to be restricted at present to the northern island, it would appear desirable, however, to divide it into four divisions proportionate to the population of the different provinces, in order to give each not only a fair share of its protection, but of its cost.

With this view it would appear right to distribute it in the following manner, viz. :—

Auckland, 200	40 Mounted 100 Europeans 60 Natives	Police.
Wellington, 125.....	25 Mounted 65 Europeans 35 Natives	Police.
Hawke, 100	20 Mounted 50 Europeans 30 Natives	Police.
Taranaki. 75	15 Mounted 40 Europeans 20 Natives	Police.

The officers and non-commissioned officers to be appointed by the governor in the proportion of say one officer and one sergeant to every twenty-five men. Inferior non-commissioned officers can be taken from the ranks and appointed as required.

Although the numbers above detailed appear small in proportion to the extent of country requiring protection, the fact of a certain number of armed men being located in certain districts, ready at a moment's notice to support the law, will have a very salutary effect to check crime, especially on natives.

Such a force to be thoroughly efficient must be carefully selected, and none but good, active, able-bodied men employed. To ensure such

good men, liberal pay must be given, to compete with the price of labour in this country; and liberal grants of land should be made eventually to induce good men to continue to serve as long as required, and to conduct themselves well.

Military Settlements.—With a view to form military settlements when the services of this force can be dispensed with, every man should be encouraged to clear and cultivate ground in the vicinity of the several stations, which ground might be so arranged as to form part of their future grant as a town or country lot, according to circumstances and position.

When not employed upon their own land, or upon other duties, the men might be most advantageously engaged in opening out and draining roads leading to their several posts, clearing underbrush, bridging swamps, and doing similar works of public utility.

Defence of Settlements.—The scattered unprotected state of the outlying settlements, that is, of the homesteads lying wide of the centres of population, renders it advisable to arrange some plan to guard against the loss of life and destruction of property which must accrue, should the settlers abandon their farms at the outbreak of native insurrection.

Although it would perhaps be impossible to provide for the protection of every separate farm, much may be done by a pre-arranged combination of families for their mutual protection.

Certain houses should be selected as points of refuge, on which to retire or centre on any emergency.

Such houses should be carefully selected with a view not only to defence and centrality as regards surrounding settlers, but to their position and the facilities they offer to drive in and secure all the flocks and herds in the neighbourhood.

Defensible Houses.—It is impossible to lay down any rule applicable to all the different settlements, but taking the towns as the centres, they should be surrounded by a double line of fortified houses, supporting each other as far as practicable, and depending upon the towns for assistance when necessary.

Beyond the selection of such houses, but little is necessary until there is occasion for alarm. Native insurrections do not break out without considerable warning. When the warning is given, each house should be made bullet proof, about 6 or 7 feet above the ground, and loopholed above this line. Tables and chairs form an excellent "banquette" on which to raise the defenders to the proper level.

At point-blank range, say 200 yards, but this must vary according to the configuration of the ground, the house should be surrounded by an *abbatis*, or *chevaux-de-frise*, or even by a stout, loopholed palisade, where it is necessary to command any particular line of approach, bush, or other cover for an enemy, by throwing up a small parapet, digging a few rifle-pits, or enclosing a small space with palisades at the angles, so as to give a flank fire along the outside of the enclosure. No natives would dare to approach; much property might be saved; and the melancholy spectacle of another devastated province avoided.

Natives have no powder and shot to waste in killing cattle or sheep

when at war with Europeans, so that all animals driven within the enclosure would be comparatively safe.

**Stockades or Blockhouses.*—In populous districts, when a considerable extent of cleared land can be commanded, small detached works might be erected at eligible points—flanking each other, and protecting the area enclosed. Experience has proved that natives do not like to commit themselves by penetrating between detached posts; they do not like exposing themselves on open ground; and, although it would not be possible to garrison every house selected for the purposes of defence by troops, or by police, a few men might be told off to different localities, who, with the men of the neighbourhood, would hold such defensible positions against any number of Maories, unless the latter, from impunity, become much bolder than they have hitherto shown themselves.

A good well of water, a supply of provisions for ten or twelve days, and a good stock of firewood would enable a very few determined men to resist a very superior number of natives.

In this manner a small number of men would protect a large extent of country against savages armed only with *muskets*, many of which are in bad order; and with few of which can they fire with certainty for distances exceeding 150 yards.

* An account of the Omata stockade, a class of outpost highly approved of by Colonel Warre, and a description of which he forwarded, will be found in a previous No. of the Journal, No. XXV, March, 1863.—Ed.

No. I.

BATTLES WHICH HAVE BEEN LOST BY THE NEGLECT, ON THE PART OF THE COMMANDERS, OF ACKNOWLEDGED RULES AND PRINCIPLES OF WAR.*

By Captain H. Bond, 91st Regiment.

Principle 1st to be discussed—

In an order of battle, never choose ground which has its tactical front intersected by natural obstacles, such as ravines, brooks, morasses, &c., running at right angles to, or across the direction of its length, so that support cannot be brought from one part of the line to another part, or at least cannot be sufficiently quickly brought to the assistance of another part; of which error the enemy may profit, by attacking the isolated part of the line, with an overwhelming superiority of numbers; thus destroying in detail the isolated parts of such line of battle.

The above principle I have illustrated by a brief account of the two battles of Ramillies and Dresden—the former fought in the year 1706, between the French army, under Marshal Villeroy, and the Confederate armies, under the Duke of Marlborough; and the latter fought in the year 1813, between the French armies under Napoleon, and the allied armies of Russia, Austria, Prussia and Sweden, under the Prince Schwartzenburg.

Battle of Ramillies.—The most elevated part in the plains of Brabant is the tract of land between the sources of the two Gheetes, the Mehaigne and the Deule. These streams, finding at first but little descent, render the ground marshy towards their rise, partially swampy along their whole course, and, in some places, even impassable. The banks of the Great Gheete are steep; those of the Mehaigne and Little Gheete, less abrupt. The ground, rising above them, forms a plain, the surface of which is dotted with coppices. That portion which was the scene of conflict, is divided into two parts by the Little Gheete, the eastern is called the plain of Jandrinœuil, and the western the position of Mont St. André; from a village on the Gheete, which forms an equilateral triangle with Autre Église and the tomb of Ottomond. From this tomb or barrow, which crowns the highest point of the plain, and overlooks the marshes bordering the Mehaigne, the position extends as far as Ramillies, near the head of the Little Gheete; and, then, following the marshy course of the rivulet, is continued to the rising ground on which Offuz is situated. From Offuz, bending forward on the left bank of the stream, it proceeds along the verge of the eminence to

* Pressure of other matter has delayed the publication of this paper.—Ed.

Autre Église, where it terminates in the fork made by the confluence of the Little Gheete and the Jauche.

The French position extended from Autre Église, where their extreme left rested, to the Tomb of Ottomond, where the right, consisting entirely of cavalry, 100 squadrons, including the King's household cavalry, formed in two lines on the plain in front of the tomb, with intervals between the squadrons. The left stretched from Autre Église to Offuz, both of which villages were strongly occupied; these villages, with the position between them, are enclosed by the two branches which form the Little Gheete, besides a vast morass stretched in front and almost round the position, along the banks of the Little Gheete, thus totally separating this portion of the line of battle from the centre and right. They could only be approached by a circuit to the rear; no direct communication between the centre and left existed, so that the left, though so strongly posted as to be impregnable to the assault of the enemy, could not give assistance, or receive it readily. The centre extended from Offuz along the high ground behind Ramillies, into which village 20 battalions were thrown. The right, as above stated, consisted only of cavalry; to protect the right, the French posted a brigade of infantry at the bridge of Tavières, situated about a quarter of a mile in front, amidst marshes and inclosures. Light infantry occupied the hedges and inclosures, the marsh of the Mehaigne being everywhere impassable except at the bridge of Tavières.

Although this order of battle was formidable, the defects of the position were too obvious to escape the penetrating eye of the British commander. From its concave shape, it afforded great facilities and advantages to an assailant, who performing his manœuvres on the chord, while the enemy must traverse the arc, on account of the natural obstacles of morasses, drains and inclosures, &c., contained within the position, could bring a superior force into action, at a given spot in a given time. He noted, that the left wing would be cramped in its movements by the nature of its situation, and prevented from attacking by the morass, which also protected it from aggression. He perceived, likewise, that the Tomb of Ottomond was the key of the field, and that Tavières was also too far in front, either to give or receive protection. He judged, therefore, that to facilitate an attack on the hostile right, it would be requisite to derange their dispositions by a feint against their left, a manœuvre which would compel them to strengthen the point menaced, and weaken that which was the real object of attack. Finally by carrying Tavières, he would uncover the flank of the horse, and by gaining the commanding point of the Tomb of Ottomond, enfilade the whole position. With these objects he formed his plan. He ordered the British, Dutch, and German infantry, composing the right, to march down the heights of Foulz in two lines, sustained by the cavalry, and form a demonstration of attack against the villages of Autre Église and Offuz. The stratagem produced the desired effect; for no sooner did Villeroy discover his left to be menaced, than he drew a very considerable reinforcement from his centre, which marched with the greatest alacrity to reinforce the detached troops about Autre Église. While these were being re-

placed by part of his infantry of the right, and the hasty movement had somewhat disordered the hostile lines, Marlborough directed his own right to face about, and reascend the heights, from whence the first line alone would be visible to the enemy. As soon as the second line, now foremost in retiring, had passed the crest of the ground, and was no longer in view, he directed it to march rapidly to the left, and form in rear of the left centre, with the twenty squadrons of Danes as a third line, behind the cavalry of the left wing. Four battalions of infantry, with four guns, were detached from the left, and formed near Boneffe, with orders to march parallel with the cavalry, and dislodge the enemy from Franquenay and Tavières; and twelve battalions, under General Schulz were also detached, or rather selected from the left, to form an attack on Ramillies.

It will now be seen how Marlborough, having succeeded in deluding Villeroy to thin his centre and right, what a numerical superiority of force was brought to bear by him on Tavières and the French right. Tavières was assaulted and carried. Villeroy being now convinced that it was his right that was the real point of attack, ordered up reinforcements, but it was too late. The Danish horse intercepted the reinforcement, which consisted only of 14 squadrons of dismounted dragoons, who were cut to pieces and driven into the Mehaigne. The French cavalry were now charged by the allied cavalry of the left, who, after a desperate conflict, with constantly changing and fluctuating success, finally drove the French horse on to their centre, round Ramillies, which village was stormed by a superior force under General Schulz, viz., 12 battalions of the left, with an additional force of 20 battalions from the centre. The village was carried, and its defenders cut to pieces. The result of the battle up to this point was as follows: the cavalry of the left wing, assisted by 20 squadrons of the right, which had just arrived to reinforce the attacking cavalry, crowned the heights of Ottomond, formed in four lines, in a direction at right angles to the French original line of battle, or first position; the infantry of the left and centre having carried Ramillies, changed front to the right, forming a line at right angles to the French first position. The French line, with its right turned, had thus its right and centre driven upon its left, upon Offuz and Autre Eglise, where Villeroy was vainly attempting to rally and reform the broken and beaten French army. Thus, the French Marshal lost the day, from having chosen a position, in which parts of his line were separated from other parts by natural obstacles, which prevented assistance coming to the attacked portions, which in this instance were his right and centre, which had been assailed by a numerical superiority of numbers, and destroyed in detail; and all reinforcements which attempted to arrive, having to move on the circumference of a circle (which was an additional disadvantage) on the point of attack, were also received by superior numbers, and destroyed in the same manner. The rest of the battle was a continuous defeat; the allied right, with that boldness which characterised the proceedings of the day, advanced, and having succeeded in crossing the morasses of the Jauche and Little Gheete, came down upon the extreme left of the French army, thus placing it

between two fires. The whole French line gave way, and the retreat which was proceeding in comparative good order at first, as the steep banks of the Great Gheete and the depth of their front gave the enemy security, was suddenly converted into one of those unaccountable panics, which the best of troops are sometimes subject to. It happened as follows: the Spanish and Bavarian horse guards, under the Elector of Bavaria in person, was endeavouring to cover the left of the French army as it moved off the field, when two regiments of English horse overtook them. The charge was irresistible, the horse guards were broken and ridden down. The fate of the regiment struck such terror into the waving mass of the French army, that the whole army lost all control, broke their ranks, threw away their arms, and while hundreds threw themselves down the banks of the Gheete into the stream, others scattered all over the country, like a scattered swarm of bees. As the jammed-up and overturned baggage-waggons prevented all escape along the direct rear, the roads became obstructed, and an immense crowd pressed together; here the British cavalry made a terrible slaughter, and took thousands of prisoners. Almost all the cannon, and the whole of the baggage fell into the hands of the victors, who continued the pursuit with unabated vigour, until two in the morning. The loss of the French amounted to 15,000 killed, wounded and prisoners. That of the victors to 3,600 only.

LECTURE.

Friday, February 13th, 1863.

W. STIRLING LACON, Esq., in the Chair.

ON SCIENTIFIC PHYSICAL TRAINING AND RATIONAL GYMNASTICS.

By M. Roth, Esq., M.D.

A few weeks ago a gentleman connected with this Institution called on me because his attention had been directed to some of the means for scientific physical training which I had placed in the International Exhibition, and for which the jury had awarded a medal. After having explained to this gentleman my views on scientific physical training, and the prevention of many diseases and deformities, I was invited to communicate these views in this Institution.

Although I am neither a lecturer nor a public speaker, I have accepted this invitation from a sense of duty, and relying on your indulgence I hope that you will excuse the ungrammatical construction as well as the bad pronunciation of my English.

I say a sense of duty induced me to come here, because I wish to act according to a quotation from a French writer—a quotation which I have made use of frequently, namely:—

It is the duty, the bounden duty, of whoever has an idea which he believes useful, to publish it for the common good.

Whatever you know to be useful, and good to be known by every one, THAT *you cannot conscientiously keep to yourself.*

My Motto is—Prevention is better, easier, and cheaper than cure, and as scientific physical training includes the means for preserving health, I believe such training to be useful, and good to be known by every one; I will, therefore, not further apologize for bringing before your notice a subject which is of some interest to everybody; because I am sure you will agree with me that there are many more agreeable ways of spending your money than for medical

fees and for poor-rates, which last are always higher in proportion to the greater neglect of scientific physical training of the masses.

The highest aim of medical science is prevention of disease, and my attention has been especially directed to this branch in consequence of the ailments of long standing, and of bodily deformities of every kind, which for more than twenty years I have had opportunity of observing; the majority of these cases have been traced to the neglect of the science of physical training, and of the elementary laws of health, or in other words, to ignorance, indifference, and neglect.

Without stating the results of my personal experience, I will read a few facts extracted from official reports, you will then be able to judge whether it is worth while to think of physical training, whether our *public and private schoolmasters and schoolmistresses* are to continue to restrict their instructions to reading, writing, and arithmetic, without paying the slightest attention to bodily training; or whether it is time to introduce some reforms in our training-schools, and thus prepare a staff of intelligent teachers whose task will be *to educate mind and body simultaneously, and who will not train the one without the other, but will guide and lead them like a pair of horses harnessed to one pole, as Montaigne proposed.*

The following are the few facts to which I beg to call your attention:—

"In 1860, 27,853 recruits were examined at the head-quarters of the recruiting districts for the army, and 7,128 of them, or 256 per 1,000 were found UNFIT for military service. This number does not include ALL rejections, for 11,054 were secondary inspections; that is, inspections after the men had been examined and accepted at out-stations, where, of course, there must have been rejections.

"Of the 16,799 primary inspections, 318 per 1,000 were rejected; while in France, in 1859, the rejections were *only* 317 per 1,000. I say ONLY, because in France *every* man is liable to be drawn for service; and the proportion would be probably smaller if the enlistment would be voluntary, as in England.

"In the various recruiting districts the rejections per 1,000 amounted in Glasgow to 43 per cent., Belfast to 42 per cent., London to 33 per cent., Bristol to 20 per cent. The rejections amongst the Scotch are 31 per cent.; Irish, 25 per cent.; English, 24 per cent.; Welsh, 23 per cent.

"Two-fifths of all rejections were for causes indicating general bad health, an item = 0·126 per 1,000. One-fifth for causes which would affect the soldier's powers of marching = 63 per 1,000."

On comparing the causes of rejection, I find that England has the highest proportion of small and malformed chests, and curvatures of the spine. Scotland excels in loss and decay of many teeth, which is deemed a symptom of bad health, defects of both upper and lower extremities, and varicose veins. Ireland has the largest number of diseases of the eyes. Having mentioned varicose veins, I wish to point out that while the *French* have 10 per cent., the English count 28 per cent.

Half of our recruits examined in 1860 were described as labourers, husbandmen, or servants. One-fourth came from mechanical occupations, which are in general favourable to physical development, as carpenters, smiths, masons, &c.

The proportion of rejections with regard to occupations is also instructive; amongst mechanics the amount of rejections was 27 per cent.; manufacturing artizans, 26 per cent.; labourers, husbandmen, and servants, 25 per cent.; shopmen and clerks, 23 per cent.; professional occupation and students, 16 per cent.

Of 530 candidates for railway employment, 201 were rejected. The chief causes of rejection were small and malformed chest in 92 cases. This is from the report of the medical officers of the Great Western and its Associated Railways Provident Society for 1862.

It is a blessing that our female population is not enticed by the recruiting sergeant to accept the shilling, and if I were obliged to state the amount of rejections amongst females, the number of those who are unfit for hard work would exceed *fifty* per cent.; because we must add to the complaints of the rejected recruits all the bad effects of tight dresses, of corsets, stays, bodices, waistbands, busks, and of other injurious influences, by which our female population only is affected. How numerous the complaints arising from these causes are, every medical man who has paid some attention to this subject is able to state.

People unfortunately believe that illness under every form is a dispensation of a higher Power, and that they can but submit to it, and thus they try, only when ill, to recover health.

Many are not aware that a kind Providence has given us the means of preventing a large amount of diseases, the majority of which are but a certain and necessary effect of causes, which could be removed if we would not neglect the elementary laws of health revealed to us for our own well-being, as well as for that of our less educated fellow-creatures.

These laws form a most important,—I may even say *the* most important part of all scientific physical education, the object of which is the simultaneous and harmonious development of the bodily and mental faculties; such a development is the basis of a sound constitution, and enables the will to control the body, and the body to obey the demands of the will; sound physical education enables us in any condition of life to move and to act with caution and firmness. The beneficial action of mind and body when sound being mutual, a certain amount of energy is produced, which has the most beneficial effect on our moral, intellectual, physical, and bodily faculties.

If the will has, within reasonable limits, perfect control over the well developed body, we can not only resist with more ease many injurious influences, but also preserve our individuality while in contact with the external world; being exposed not only to external influences, but also to the attacks of others, it is important that we should be able to defend ourselves against these attacks, and therefore rational physical education serves as a first step to prepare us for the defence of our homes and our country.

These few remarks show the connection which exists between physical education and military gymnastics; that all those who are entrusted with the mental education of the young and adolescent should also be able to conduct their bodily education; at present, with very few exceptions, only *uneducated* persons have the care of the bodily development of the growing generation, and they are expected, by a merely mechanical drill, or by falsely called *calisthenic* exercises, to produce that harmony of the various bodily and mental faculties which it is impossible to do without previous training, and without the knowledge of the structure and functions of the organs of the human body, and without the knowledge of the laws which govern the right development of the human frame.

The drill-sergeant and the dancing-mistress are the persons who in the majority of educational institutions are resorted to for the physical education of the young.

The drill-sergeant is engaged to drill the boys and girls once or twice per week. He does this most conscientiously, and exactly as he is accustomed to drill the adult recruits, according to the directions of the manual of drill as published under the sanction of the authorities.

The dancing-mistress tries her best to give the young gentlemen and ladies by calisthenic, or at present by what she calls the fashionable Spanish exercises, or by exercises with the chest expander or any other exercises, the appearance of what is usually called *a good figure*.

The few persons who think about physical education at all, believe that climbing on poles, ropes, and ladders, leaping, and athletic exertions of *any* kind, as used in the majority of gymnasia, are all that is necessary for the development of the body; the consequence is that gymnastic apparatus are provided on which the pupils may hang, swing, or make any *tour de force* at their own option; *the principal aim is to produce brute muscular strength;* all rational instruction is necessarily neglected, because the teachers themselves have not even an elementary knowledge of the manner in which the body is formed, and for what purpose its various parts are wanted, they do not know the injurious influences to be avoided in order not to interfere with the free action of the lungs and other organs, as well as with the natural growth, development, and movements of the body and limbs.

The non-interference with the natural development of the body is one indispensable part of a scientific physical training, which can be completed only by *rational* gymnastics, that is, gymnastics based on anatomical and physiological principles.

There are many *systems* of gymnastics, but there is and can be only one *rational* system of gymnastics; we owe the development of this science to the *genius* of a countryman of Linnæus, the Swedish patriot and poet, Ling.

The models placed before you, the originals of which are in the Kensington Museum, refer to that part of the physical training which may be called the *non-interfering section*, while these figures, drawings, books, &c., serve for the instruction in the various branches of *rational* gymnastics.

The fact that people are much more impressed by what they see

than what they hear, and that they learn easier by what strikes the eye, induced me to form a collection of models for the instruction of those who have the care of the young—mothers, nurses, governesses, schoolmasters, and especially schoolmistresses. I say especially schoolmistresses, because these most important persons ought to be well informed in all matters concerning the health and the physical training of the young, of whom at present 40 per cent. die before the completion of the fifth year, while of the remaining sixty, if boys at the age of 20, at least twenty-two are unfit for military service, or railway employment; and if girls, at least thirty are unfit for hard work. If every schoolmistress were well instructed in these subjects, she being a centre acting on an average number of fifty to sixty girls, who in their turn will be wives and mothers, there would be some hope that in the next, or third generation, the fruits of scientific physical training would be visible, and that every English woman would be the officer of health in her own house, and that the rejections of our recruits would be under 10 per cent. There is no intention on my part to exclude other persons from being trained in the subjects I have named; my object is only to point out *one* of the many practical modes by which, according to my humble opinion, the physical state of the masses would be improved.

There are ladies' and other colleges, training schools, where instruction can be obtained in all branches of science, except in that of physical training; certificates are given to the future governesses and tutors, to the masters and mistresses, that they are capable of instructing and taking care of the pupils, although they have not the slightest idea how to preserve their own health or that of their pupils. The consequence is that many of these, in other respects, excellent persons believe it to be beneath their dignity to attend to the physical development and training of those placed under their care.

The society for the employment of women has a large field of female occupation open to those who wish and seek for employment which is healthy, useful, and will be remunerative, because *educated* teachers of physical training are wanted; many families who do not wish to send their children to the dancing academy, would be glad to avail themselves of the services of such female teachers.

If we wish to have strong soldiers, sailors, and working men, we must first think of their mothers, who have the difficult and responsible task of rearing them in infancy and childhood. This opinion is shared by many of my professional brethren. Other eminent men begin also to pay some attention to the subject, as for instance the Very Rev. the Dean of St. Paul's, Dr. Millman, from whose address as chairman of the educational section at the International Social Science Congress, the following lines are extracted:—

> There was, however, an education anterior to that of school—the education at the mother's breast; and as to that they might depend upon it that the best educated female would in general be the best mother, and do her duty best to her infant children. But this, above all, should be recollected, that the first duty of national education was the *health* of the children. A sickly child might be very intelligent, over-intelligent, but in general, quickness of intelligence would be much affected by animal spirits, and animal spirits rested on healthfulness.

Although the physical, moral, and economical advantages arising from a *system* of physical training have been clearly shown in evidence before the Royal Educational Commission, there is still at present but very little hope for the general introduction of scientific physical training, because its bearing upon diminution of infant mortality, upon prevention of diseases, and consequently upon diminution of poor-rates, as well as upon the general increase of the population, and their working efficiency, their greater power of defending the country, and of colonising the various parts of the globe belonging to this empire, are not yet sufficiently understood; the greatest impediment is, that we are accustomed to pay for the diminution and removal of an evil when developed, but we do not like the cheaper course of prevention; there is a want of encouragement on the part of the legislature, and no inducement is held out to the teachers of schools under Government inspection to give up a part of their time to the introduction of a branch of education, which is not yet considered necessary, and for which, as it is not obligatory, no remuneration is awarded. I am sorry to be obliged to repeat a passage written ten years ago, in a letter addressed to Lord Granville, at that time, President of the Council on Education. I was then advocating physical training, and the introduction of rational gymnastics as a very important branch of national education. The passage is—

> We have cattle-shows, exhibitions of poultry, distributions of prizes, and medals to the trainers of beasts for improving them. There are, humane societies, philanthropic enough to reward a man who has saved another from drowning or fire; but what is there to reward those whose life is devoted to the mental and bodily improvement of our fellow-men? Would it not be desirable to encourage the zeal of educators by offering prizes to the man, who, by his moral and physical training, has brought up the greatest number of healthy and well-educated pupils? How is it that blind, dumb, and deaf children, idiots, and other unfortunates, are taken care of, while we allow so many, originally healthy and able-bodied children, to become crippled in body and mind by the ignorance of their parents respecting the most necessary and simple means of preserving health? How many more lives might be saved, and human beings preserved from disease, poverty, and crime?

These introductory observations will be sufficient to give you some idea of the general views I entertain on the subject of physical training. I beg you to understand that one main feature of the system is the non-interfering with the development of the human body.

At present people think of training soldiers when they are twenty years old. That is very hard work. They can be drilled to do certain things; but if you wish to train them to be more than mechanical instruments, it is desirable they should be able to place the body under the control of the will, and in order to produce this general influence of the will upon the body, it is necessary that the education of the body should go hand in hand with that of the mind from the earliest school period—I mean from the time they begin to go to school; and this training must be continued through the different stages of their growth, and then we shall be able to have soldiers in a much shorter time; because if I give a man a general power and influence through his will to act upon his body, what he has to do

becomes very easy to him: but if you take a man whose mind has never been accustomed to act upon the body, the task is very difficult. Therefore, physical training is, at the same time, a mental training, and the means which we use to develope the body are, at the same time, means to develope certain of the faculties of the mind, because a certain amount of order, exactitude, energy, quickness, and a certain degree of mutual assistance, will be produced if we train body and mind mutually.

Before I begin to speak of the second or active part of physical training, by which I mean rational gymnastics, I wish to point out, that there are certain agents, without which we are not able to live, agents of which people in general do not think so much as they ought.

For instance, we are not able to live without a certain amount of air. I have had opportunities of visiting workhouses, and of seeing how the children are reared in them. Upon going into a room, I have found five or six ventilators, but they have all been closed. Lately, through the aid of the Ladies' Sanitary Association, we made a move in one of the large training schools to introduce some sanitary knowledge and physical education. I have found as many as 200 schoolmistresses occupied in very large rooms, and I have been scarcely able to breathe when I entered. I enquired about ventilators; there were plenty of ventilators, but they had not been opened. Now, the object of this apparatus before you, which is simple and cheap, is to give you some idea of how it is possible to have a constant admission of fresh air without the power of excluding it. This model was suggested to me by a gentleman in the Exhibition, and I believe some mention of it was made in the *Builder*. In the lower part of it is a piece of wood which prevents the lower sash descending. Through this space, between the two sashes, a current of air will constantly arise, without producing a draught in the room. It is called *inexpensive ventilation*, because the only expense is to have this piece of wood, which can be taken out if required. That is the whole apparatus. It is so practical and good, that I thought it my duty to mention it here. Here is another apparatus, that I can show in this model also, suggested by the same gentleman, by which you can have twenty-five feet of window open, without producing draughts. It consists simply of an oblique curtain, the air rises up, and does not interfere with the comfort of the people in the room. For schools there is another contrivance; it is the best for schools, or where there are a number of people congregated, because it is placed at a considerable height, and people in general will not take the trouble to close it; indeed, it is intended never to be closed. I have another ventilator of iron on the same system as the first, like a Venetian blind, which cannot be closed entirely. They are used very much for barracks, where the extent of superficial surface must be in proportion to the number of persons in them.

Ventilation is, in my opinion, a most important part of physical training, because people are not able to restore and purify their blood without a constant influx of fresh air. We are better able to digest

everything we eat, where we have a large supply of air. This is the reason why labourers living in the country are always able to digest coarser food than persons living in towns, although at night, from the arrangements of their dwellings, they may not have so good a supply of fresh air.

Another subject in relation to physical training is food and drink. The Registrar-General finds the largest amount of disease of the digestive organs in Scotland, which is attributed to the use of coarse food, and the unscientific way of cooking it. This matter of diet is also an important object with those who have to deal with physical education, because air, food, and drink, are the materials of which we are built, and without which we cannot be built up; consequently, if the child has not a sufficient supply of the proper materials for its growth, it is impossible for nature to produce physical strength. I have frequently given the advice to give daily a piece of bread to weak children whose want of strength depended only upon insufficiency of food.

Another indispensable agent is to have a certain amount of warmth. We produce, through our own natural functions, warmth in ourselves, besides which we have artificial means of retaining this warmth by the aid of clothing. Inasmuch as military men suffer very much, when on the march, from being improperly shod, I have thought it desirable to bring here some models of shoes as they ought to be made, and to show how a foot is to be developed, and what are the general bad influences acting upon its development. In the skeleton of the foot we find the big toe is very straight, quite in a straight line with the other toes. Here are casts of the feet of a few children whose parents have taken care of this point since they were born, and you will find the big toe is as straight as it should be. There is a model of another foot, where the big toe has begun to move on one side and to approach the next toe, instead of remaining in a straight line. Another example will show how one of the toes is already pushed out. The result will be that as the foot continues to grow a badly-formed foot will be produced. Here is a specimen of what is wrongly called a beautiful foot. We see ladies dress in tiny boots, and this model shows the deformity of the foot when taken out of that tiny boot. Here are two boots made for the same foot. One has the high heel, the narrow sole, the pointed toe, and high instep; the other, which is made to accommodate the natural form of the foot, has a very large basis and no heel. I am sure, if we were destined to have a high heel, nature would have given it to us. The shoe which I propose for a man, as it should be worn, is made with a bend in the sole, which is not required to be elastic. All that is necessary is to have the bend thinner, wide soles, and the inner side of the boot in a straight line. This is the most comfortable boot, and it will enable a man to march much better and much longer than any other kind of boot. We find that a great obstacle to the adoption of the proper form of boot lies partly with the public, whose ideas of a beautiful foot are wrong, and partly with the shoemakers, because, everything now being made for the trade, and on a large scale, they do not like to make an article which is not yet generally used, and which wants any

particular care in the making. So that, should any shoemakers wish to do the right thing, they would meet with some impediments. I point this out because one great object towards the adoption of a proper physical training is to change our ideas about certain matters. I am told that among soldiers, boots are not worn with comfort until they have been torn and mended again in the barracks. How far that is true I do not know, but it was mentioned to me as a fact when I made enquiries on this subject. Many of the rejections of recruits, in consequence of complaints of the foot which affect the powers of marching, are partly the result of this cause—the improper form of the boot. I have been told by another gentleman, that in some parts of the country they wear boots of the weight of 14lbs. It will explain how difficult it is for them to march if that is the case; and if, in addition to this, they have not the right form of boot, you can easily understand how the development of the foot is prevented, and that the men are unable to perform their duties. Short and tight stockings aid in producing deformed toes; these models show divisions for each single toe, and may be called foot-gloves. In the other model, is only one division for the big toe; such stockings have proved very useful in some cases of deformed and compressed toes, and I may say that they prevent the pushing out or down of single toes, which is frequently caused by narrow shoes and boots.

I am sorry I am not honoured with the attendance of a larger number of ladies, because what I have mentioned in regard to the foot applies equally to the chest. If you look at this figure, which shows the natural development of the chest, you will see that the external lines of the space in which the lungs are enclosed, are almost round or oval. But the form into which the chest is usually compressed is different—the external lines are angular. I have sent to a shop in Oxford Street for a stay such as would be worn by people of the working class, as I wished to say something on this subject. I did not like to send to a fashionable staymaker's, where the compression is carried to a still greater extent. Now, stays such as these interfere very much with the action of the lungs. But so long as gentlemen admire this form of waist, there is no hope that the ladies will give it up. In short, the object of my bringing this subject forward, is not to blame the ladies, but to tell the gentlemen that so long as they admire this deformed figure of a lady, and say, "Oh, I can span her waist! oh, how beautiful!" so long will it be perfectly useless to induce the ladies to relinquish the bad habit of wearing tight stays. It does much mischief, for though it may not matter with fashionable ladies, who have their doctors and can remain at home, it is imitated by the middle class and the working class, and it produces a very bad effect. Therefore, gentlemen, do not blame the ladies, but blame yourselves. So long as you do not change your ideas of beauty, so long as you think a curved line is ugly, and an angular line is pretty, we have no reason to expect that any change will take place.

Besides dress, there is another important part belonging to this non-interfering principle, and that is the action of the skin. I have therefore brought here some models of a bath, which I recommended

more than twelve years ago for introduction into barracks, men-of-war, and workhouses, where a large number of people are congregated together. It combines the full-bath, the shower-bath, and the hot-air and vapour-bath, and being mounted upon wheels, can be used not only in hospitals and barracks, but also on the march and in camp, and, if necessary, it can be used as an apparatus for washing linen, and also for cooking.*

Then, again, there is another injurious influence which acts against our natural physical development, and that is, the injurious positions in which our bodies are kept. To give an insight into this I have prepared a table of some injurious positions. The first are some of the injurious positions as they are going on in the working classes, and some others as they are going on in the better classes during the time of education. So the table is called "Injurious positions during growth and education." It will give some notion of the effect of these bad positions. For instance, how little girls having to nurse children, begin to get crooked before they are grown up; besides this, they have to encounter the injurious action of a hard wooden busk in their stays. You can fancy what a bad effect would be produced by such an instrument upon the body in conjunction with the stooping posture necessary in nursing. Then, again, needlewomen have to work in low rooms, in a bent position, where there is no ventilation, and plenty of gas and people.

This anatomical figure before you, is for the purpose of showing the development of the lungs, and how injurious it must be to have these compressed. This is an invention of Dr. Auzeaux, and very useful for the purpose of teaching the elements of the structure and functions of the human body, the knowledge of which is indispensable for those engaged in scientific physical training.

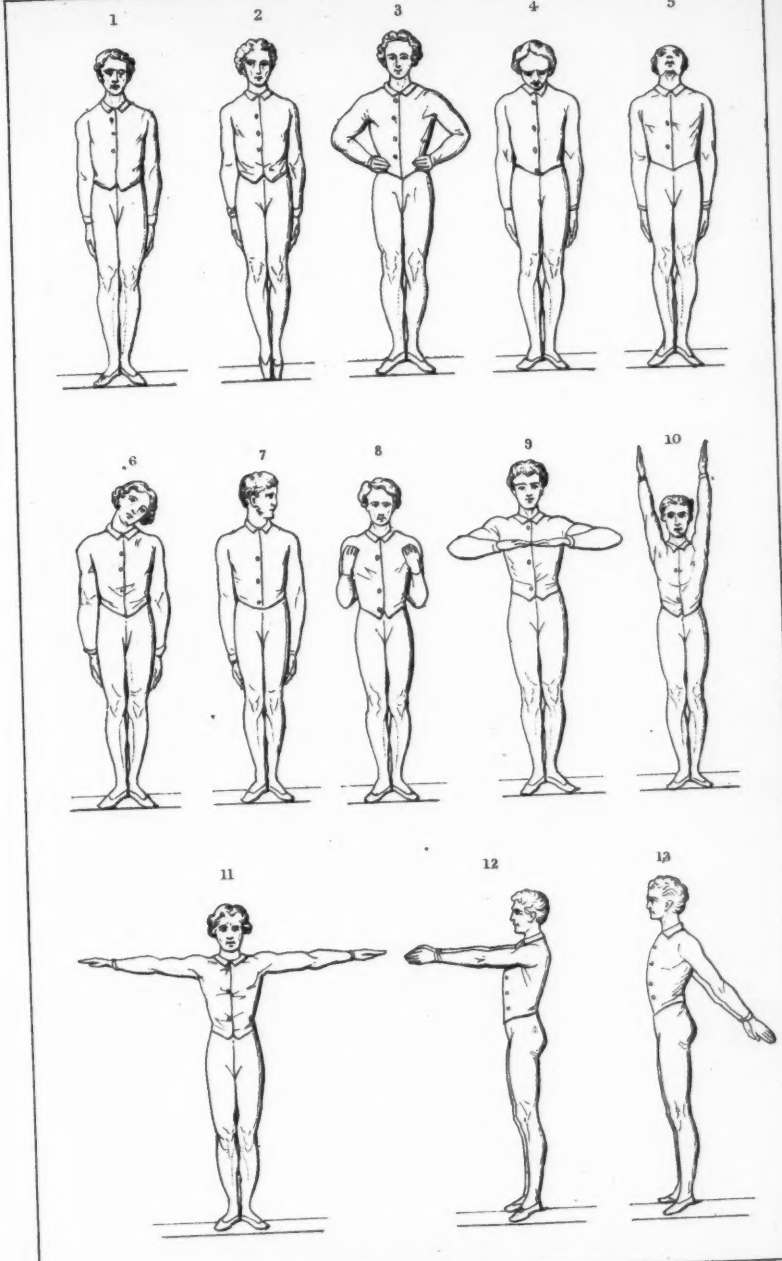
We come now to the point of rational gymnastics. I repeat there is only one good system of gymnastics, that which takes care of the human body. It should not be the object in a gymnasium to see who can climb the most, who can vault the best; but the object should be to produce harmony of the different parts of the human body, consequently, every part should be simultaneously developed. The figures before you have been modelled by an eminent French artist, under my own superintendence, in order to show the elementary actions of the human body on which all other movements are based. The figures will show the various positions in which the elementary movements can be executed. The positions must be compared to the various keys in music, because the same movement in a different position produces a different effect. Figures 1, 2, 3, (Pl. xvii) show different positions of the hands and feet; 4, 5, 6, 7, different movements of the head, as thrown forwards, backwards, sideways, and turning. These flexion and turning movements can be combined in various ways. Figures 8, 9, 10, 11, 12, 13, show the elementary movements of the arms. We use the arms in all directions, but here we have only

* Such baths have been made by Messrs. Teaks and Son, in Great Russell-street.—M. R.

the principal directions of the space, viz., to the body, arms bent fingers touching, upwards, outwards, forwards, and backwards. You will observe that the difference between these and the so-called extension movements in the army is, that in these movements the hand is always stretched, and the fist is not clenched. When we have the hands clenched, a certain set of muscles at the back of the forearm are not brought into action. Other figures show elementary movements of the trunk similar to the movements of the head. We have actions to the right, to the left, forwards, and backwards, and two instances of combined movements: see figures 14, 15, 16, 17, 18 and 19 (Pl. xviii). Figures 20, 21, 22, 23, show the movements of the feet.

By forming a combination of these elementary movements of the different parts of the body, we have a basis upon which you are to act. Just as with the twenty-four elementary letters of the alphabet we can form endless combinations and also talk much nonsense, so it is with these elementary movements of the human body. Our object is not to make the greatest exertions in any one direction, and to do as many exercises as possible, even injurious ones, but to combine these movements for purposes that are useful in life. Our object is not to form tumblers, rope-dancers, &c., but to develop the powers of the body harmoniously; therefore we seek the combination of these simple ideas. The same movements which are necessary for the first educational development of the body can be also made use of for the purpose of mental instruction, and an intelligent teacher can teach the elementary geometrical forms by the aid of the various positions and movements of the limbs and body; thus children can be taught what a horizontal and vertical line is, the various angles formed by two-lines, circles, and ellipses can be formed, &c., as you can convince yourselves by looking at these models, which form the basis of some other very important branches of physical training. I have also tried to introduce these elementary movements under the form of gymnastic games, which afford amusement while the body is exercised.

They form the basis of military gymnastics, because men are prepared for the drill through these. The greatest and best results have been obtained in the Swedish and Prussian armies by preparing the recruit before he enters upon his military duties, by these apparently simple exercises. Although they appear simple, they are not so simple, for the man has to do them with the greatest exactitude, and he is obliged to think for himself. They are called "free exercises," because there is no external help, no apparatus, no machinery is wanted. By placing together two, three, four, five, or more men, you can make them all work at the same time, and supply to one another the place of apparatus. This is the importance of this scientific basis in comparison with other systems, that you have a certain number of men working together at the same time under a certain word of command, either as individuals, or as one compound body, without being obliged to raise heavy dumb-bells, under the weight of which the men are panting for breath. The men on the right and left can supply the weight of the dumb-bell by their power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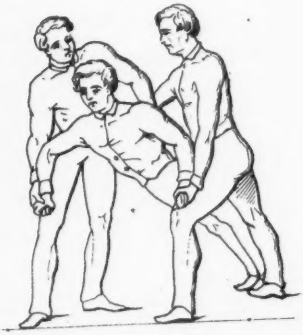

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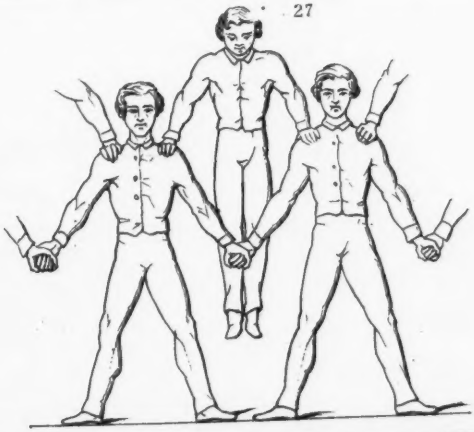


of resistance, which can be increased to any desirable extent, and if there is a living resistance it is constantly necessary that the two or three men should work together, as if they would form but one body governed by one mind. So that in fact we have not only a machine, but we have here a living body, whose mental faculties are brought into power by the exercise at the same time as the body.

Figs. 24, 25, 26, 27, (Pl. xix) will explain to the reader the mode of combining these movements, in which two or three men can take part at the same time, and bring into exercise the various muscles of the body without the aid of apparatus of any kind.

To show the importance of this system for military training, I will read the following extract from a letter just received (12th February, 1863) from Major Rothstein, who is at the head of the Royal Central Institution for Gymnastics at Berlin.*

"I am happy to say that rational gymnastics are progressing favourably in our military institutions (Kadetten und Kriegs-Schulen), as well as in all the regiments of the army; even the old Commanders who did not like this mode of physical training, acknowledge its merits.

"The free exercises of Ling have proved exceedingly useful for the development of the recruits. Here, at Berlin, the regiments of the Guard show much zeal for the practice of the gymnastic exercises.

"In the regiments in garrison in the provinces, the progress of this branch of military education varies according to the views of the commanding officers, and depends also very much upon social and other circumstances, but on the whole, progress is visible everywhere.

"The full extent of this system on the physical development of our soldiers and of our nation in general, will be shown only then when our youth shall share in the benefit of a rational physical education.

"The greatest impediment to this attainment is the fanatic advocacy of such systems of gymnastics, which aim only at brute muscular developement."†

If time permits I will try to show some of these movements with resistance with these three guardsmen, that you may see how unnecessary it is to introduce what is now supposed to be requisite, the use of dumb-bells and clubs into the army. Government, as a rule, prefers things that are not expensive; and if it is proved that the introduction of these exercises will save expense in the way of apparatus and dress, then I have some hopes that the system will be adopted.

Advantages of Free Exercises are—

a. That the movements, being very simple, are easily understood and easily executed.

* In this Institution, commissioned and non-commissioned officers are instructed in the elements of anatomy, physiology, hygiene, educational, and military gymnastics. After having passed a theoretical and practical examination, they return to their regiments, and train there a number of non-commissioned officers, who assist in the physical education of the privates.

† For further information regarding these exercises I must refer you to the following works on this subject:—

1. *The Gymnastic Free Exercises of Ling, according to the System of Ling,* arranged by Major Rothstein, translated, with some additions, by Dr. Roth. Published by Groombridge and Sons, 5, Paternoster-row.
2. *Elementary Exercises or Movements according to the System of Ling.*
3. Sheet Tables of a few Gymnastic Exercises.—M. R.

b. Much time is saved, because they can be executed simultaneously by many persons.

c. The expense for apparatus and machines is saved, and the dresses less spoiled.

d. The free movements can be executed in any place, in the open air, as well as in-doors; for instance, in schools, barracks, in the open field, in the camp, and in the bivouack.

e. As every motion of a free exercise is to be executed exactly, and as many persons are simultaneously at work, they must accustom themselves to a certain attention and precision, by which means the sense of order is developed, and the attention sharpened.

f. The free exercises produce an agreeable feeling in all the movements of the body, and develope better than the exercises on gymnastic apparatus, a good posture, and an appropriate appearance and deportment in ordinary life.

There is an erroneous opinion prevalent that free exercises are suitable only for youths, and not for adults. As long as gymnastics are not made a part of education generally, the free exercises are useful also to adults, although they may be considered only as preparatory exercises.

Without wishing to disparage exercises with apparatus, as long as they are practised with caution and within certain limits, I will mention in favour of the free exercises, that if the exercises with the aid of apparatus are exclusively or too frequently practised, the body loses its natural instinctive sense for equilibrium, instead of having it developed. The sense for form and graceful positions and movements of the body is lessened, while the sense for equilibrium in such artificial positions as rarely or never occur in life is developed.

Exercises in Gymnasia.—Notwithstanding that soldiers are inspected before they are sent to the gymnasium, in order to find out whether they are fit for the great exertions, there is too great a demand made upon their strength. This gymnastic forcing cannot be avoided, if men are, in the course of a month, to go through their desired gymnastic training. This is impossible, and the man returns, or the whole company returns to the regiment, where they have no apparatus, and, consequently, lose the little they have gained, and are as stiff as they were before. But if a system of exercises is introduced in which the mind is at work, it can be done very well, and if a man is too weak to do any of them, a second or a third person can assist him, and as no apparatus is wanted, it will be possible to give the men gymnastic education without sending them away from their regiment for a month.

Great stress is laid on the development of the chest, which is produced by what is called the Oxford system. I feel it my duty to protest against these violent exercises. I have to deal frequently with delicate and invalid ladies, whose chests are flattened and compressed; if they are not consumptive, the circumference of their chest is considerably increased, in a very short time, without the use of violent exercise. The development of the chest is accomplished by breathing, and by other movements by which the muscles of the shoulders and back are developed. In all these cases we bring the influence of the

will and the mind to act upon the part which is weakened, and that is the reason why we get rid of all apparatus.

The educational branch forms a part of the military gymnastics, that branch of rational gymnastics which teaches the exercises with the different kinds of weapons, viz., the foil, the single-stick, the sword, the lance, the bayonet, and also wrestling.

There is a third part of gymnastics also based on the educational branch, called "æsthetic gymnastics." It means the application of movements of the human body for the expression of our feelings and ideas. I have here drawings which show the attitudes of the body under the influence of different states of mind. Feelings of sympathy or kindness, affection and attention, have all oval lines; antipathy, anger, pride, and all bad passions, are shown by angular lines. The other drawings represent the attitudes in prayer, the arms being extended, and the hands raised in proportion to the fervency of the prayer. Others show the position of a person who is thinking; the natural position is, the head leaning slightly forward while the arms are crossed; in this drawing the head is more inclined, and appears to rest on the finger placed near the chin. Where there is deep meditation, the head is leaning still more forward and rests on the hand. I point these out just to show in what way rational gymnastics may be made useful.

There is another purpose to which these figures may be applied, and that is, the training of blind people. Blind people are very much neglected. In the institutions I have visited I find their chests very weak, and suffering from many complaints. As we have no other means for their instruction, I have made use of these models, and I find they answer very well. A firm in the City is publishing a series of these figures in papier-maché for the object of teaching blind people.* In order to give another impulse to the introduction of these simple exercises, the same firm are publishing engravings of these figures in the form of a game for children, so that they can be applied in schools where they have no apparatus to entice the children to do these exercises.

There is a fourth part into which I do not propose to enter here, that is, the application of these movements for the cure of disease. You find on the table several of my books on the subject, with numerous engravings, showing the positions, movements, and manipulations which are used in the movement-cure. According to the individual case, the state of health, and the nature of the disease, different sorts of movements are used, which are either passive or active, with resistance on the part of the patient or the medical man.†

* Messrs. Joseph, Myers and Co., 144, Leadenhall-street, E.C.—M. R.

† 1. *Cure of Chronic Diseases by Movements.*—2. *Handbook of the Movement-cure.*—3. *Sketch of the Movement-cure.*—4. *The Prevention of Spinal Deformities.*—5. *The Hygienic Treatment of Paralysis and Paralytic Deformities.* Published by Groombridge and Sons, 5, Paternoster-row.—M. R.

LECTURE.

Friday, March 13, 1863.

REAR-ADMIRAL R. COLLINSON, C.B., in the Chair.

ON THE CAUSE OF THE FORMATION OF BARS AT THE MOUTHS OF RIVERS.

BY W. A. BROOKS, Member of the Institute of Civil Engineers.

"WHEN we consider that our very strength and consequence as a nation stand upon our being a commercial people, it is evidently our highest wisdom to pay every attention to maritime affairs. To improve our harbours, make our rivers navigable, and to open communication by means of canals, are works becoming the genius of an enlightened people, and a certain source of wealth and prosperity."—DODD.

It was truly observed by the celebrated Du Buat, that with respect to hydraulic engineering, our errors have a very different result from those on objects of taste, luxury, or pleasure, because that result is either a real damage, or the loss of some precious advantage. Such must be the consequence of the want of information, which so generally prevails, of the correct principles on which engineers should base their works for the improvement of the bars of rivers.

Before the members of this Royal Institution, many of whom have felt what it is to have nothing but a shallow bar harbour to leeward when refuge has been required, it is not necessary to dilate upon the immense importance of understanding the cause of the existence of bars at the mouths of rivers which in their channels have ample depth of water directly the bar is passed.

That this question has not seriously occupied the minds even of those engineers to whom important public works have been entrusted for a long course of years, will be manifest by a reference to their reports and evidence on the subject. Thus, even the late Mr. James Walker, for many years President of the Institution of Civil Engi-

neers, maintained before the Royal Commission on Harbours of Refuge in 1858, that in order to get rid of the bar of the River Tyne, which in its usual condition has not more than one fathom at low water of spring tides, it was only necessary to extend piers at the mouth of the river into 36 feet at low water, and that in from 20 to 25 years, a regimen would be established at the mouth, which would give 30 feet at low water of spring tides. On the strength of this opinion, the Tyne Improvement Commissioners actually went to Parliament in 1860, and obtained an Act, authorising the proposed works, in order, as was said, to therewith convert the Tyne into "a Harbour of Refuge." Mr. Walker's theory for the improvement of the bars of rivers may be called the "theory of the inclined plane;" for in answer to question 27,734 he said: "I think the tendency would be to form an inclined plane from Shields, from the Narrows, to the outer piers. If the lower end of that distance is 39 feet in depth, and the upper end 18 feet, the tendency will be to form an inclined plane from the one point to the other." There was no substantial opposition to the Bill, or Mr. Walker's theory could not have stood against a repetition of the searching question put by Captain Sullivan, R.N., one of the members of the Royal Commission. 27,733. "But if the current is no stronger in that part of the bar, according to the enlarged plan, than it would be with the first plan, how would the larger plan deepen the bar any more than a smaller plan would?" Answer: "Simply, as I say, because the depth of water at the extended piers is greater than the depth at the inner piers."

Experience has heretofore shown, again and again, that the mere extension of piers into deep water, has failed to secure the permanence of the latter.

This inclined plane theory is, in fact, all that is relied upon by M. Guy de Lesseps and those gentlemen who signed the report of the International Commission on the Isthmus of Suez Canal scheme, for the maintenance of deep water at its northern and southern entrances. The northern pier-heads are proposed to extend two miles from the shore over the muddy bed of the sea to where there is at present a depth of from four to five fathoms. Mr. Walker, in the case of the Tyne piers, and M. Guy de Lesseps, and his coadjutors, in the Isthmus of Suez scheme, having set at nought the consideration of what would have been the condition of the bed of the sea at the pier heads, as regards depth of water, supposing the contemplated protrusions had been natural, instead of artificial, and affected by the continued action of currents and tempestuous waves. They have not reflected how pigmy would have been even a projection of two miles, when compared to the great extent of coast line, of which it would have formed a part; that in fact the alluvia brought along the coast by the prevailing set of both current and waves, would have soon filled up the dead angles on each side of the protrusion, and that the regular contour line of soundings would again be formed at a distance from the new point or headland with a depth due to their influence.

Mr. Thomas John Taylor, a talented engineer, recently deceased,

has also left in his evidence before the same Royal Commission, his views on the cause of the formation of bars. He, in reply to question 29,306, said, "That the existence of bars is to be attributed principally to the drift along the beach, or, in fact, that the bar is part of the beach, which had been cut through," or that "it is a sand-bank which, like any other, might be laid down in a sheltered situation, and without the river, it would constitute in the case of the Tyne, a continuous sand from the Herd sand to Tynemouth rocks;" and further, in reply to question 29,307, he added, "the bar is not formed by the meeting of the river water and the sea." Unfortunately for Mr. Taylor's theory, too many cases exist where rivers are found without bars, notwithstanding the effect of the presence of drifting sand along the coast, and it is also to be remembered that the sites of the bars alluded to are almost invariably situated in exposed situations, or seaward of the shelter in which the drift is deposited; and likewise that in those sheltered situations, there is always deeper water, inasmuch as the drifted sand or shingle lodged there, forms natural shores through which the current forces a deep channel, and the site of the bar is, as aforesaid, found to exist seaward of the shelter produced by the headlands.

A very common expressed theory which has long been advanced, is that the primary cause of bars, is "the transverse motion of the wave and current crossing the debouching waters of the river," and the Thames is cited by them as an example of a river in which there is no bar, because its mouth is freely open to the tidal current, and there no transverse action upon it takes place.

If this theory were correct, all bars could be removed by simply turning the direction of the seaward reach, to make it freely open to the tidal current, or to ensure that the flood current, and that of the ebb, should travel over the same line of course.

Nine out of ten who profess to be able to give an opinion on this interesting subject, the bars of rivers, hold this view of the case, and it appears plausible enough, but it is not borne out by reference to facts; thus in the case of the River Tees, of which the author had charge for many years as engineer, its sea-reach, or mouth, between the north and south Gare sands, is usually freely open to the tidal current, yet that river has a bad bar, although it discharges the drainage of a large district, and consists also of a capacious tidal receptacle.

The direction of the sea-reach of the Tees varies as much as ten points of the compass, and when occasionally open to the east, and then having its debouching waters crossed by the tide, it certainly is not shoaler than when the sea-reach bears from south-south-west to north-north-east, or with its mouth freely open to the current of the flood-tide.

The bar of the Tees is due to the presence of numerous inner shoals of sand, and a ridge of rock in the circuitous channel through the estuary of the Tees, which have the effect of penning back the drainage water of the country, until long after the tide has begun to rise on the sea bar.

The example of the mouth of the Humber is still more fatal to the theory that bars exist because the mouths of rivers which possess them are not freely open to receive the tidal current. The course of the sea-reach of that river is from north-west to south-east, while the tidal supply comes from the north; yet the Humber, notwithstanding this transverse course of the tidal current to that of its own waters, is free from a bar, or nearly free; the best of rivers having usually some feature of a bar, because at times, or during extraordinary land floods, there will be found a confliction with the young flood, or early tidal current which does not exist at rivers, which are free from that condition usually.

Thus, the Tagus has a clearly defined bar between the north and south cachops, although there is a depth of about nine fathoms upon it at low water.

The Yare (Yarmouth) is another instance of a river whose sea-reach, or course of the discharge of its waters, is crossed at right angles by the tidal current which supplies this river; yet Yarmouth harbour has been improved by the late Mr. James Walker, solely by means of piers carried into the sea at right angles to the littoral current. This, however, is a case where the elongation of the piers has carried the debouching waters into a powerful tidal current.

Another theory on the cause of the existence of bars, is that by Colonel Emy, who says that the action of ground waves "flots de fond," is the true cause of the phenomenon of the bar. Those bottom waves which have traversed the shore current, and which present themselves directly to the mouth of a river, enter, or are stopped, according to the manner in which the bed of the river is connected with the sea. If the bed of the river be a continuation of the bottom of the sea, or if it be united with it by an extremely easy inclined plane, or by a gentle curvilineal figure, the ground waves penetrate into the river. In tempests they carry with them sand, which is deposited in banks of little height, because they are able to spread, and all that is raised above a certain level, is scoured out again by the action of the current of the river during calm weather." And again, "But if an irregularity of the bottom, such as an acclivity or a steep slope exist at the mouth, the ground waves rise in encountering the obstacle, and being no longer able to continue their course under the tidal stream, because their movement ceases to be in harmony with the undulation, they are met and dispersed by the currrent of the river; and during the moment of repose that their waters find in mixing with those of the river, the sand which they held is precipitated, and quickly thrown *above* the declivity by the succeeding ground waves, which repeat the operation.

"This sand," he says, "forms the bar, which rapidly increases in stormy weather, because at that time the ground waves bring to it an abundance of materials, and deposit them as on a flat shore. The bar increases quickly, and would even rise above the level of high water, if the current of the backwater and that of the ebb united, had not sufficient force to repulse a portion." Colonel Emy then winds up his description with "flots de fond." "Behold me arrived at the principal object of

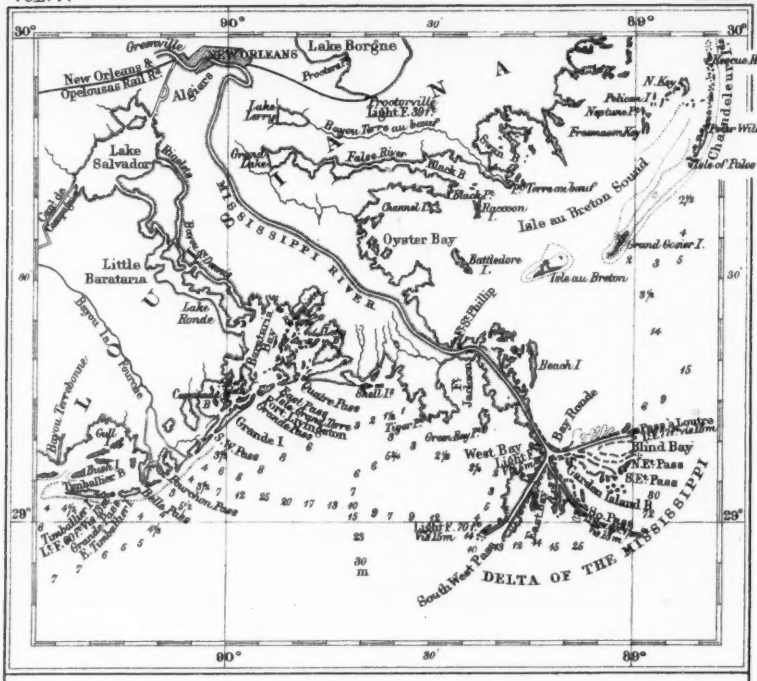
my researches, to the description of ground waves, submarine phenomena which have caused the ruin of a great number of maritime works, which have given to the sea the means to ravage its borders, and to destroy cities; which, in other situations, have augmented portions of continents, have filled up ports, have surrounded them with sands and deposits of clay, and have left, in the midst of land, towns whose walls were once lashed by the waves. All these effects have hitherto been attributed to the currents of the sea, and to the simple action of waves, but the phenomena of ground waves is about to resume their rights as formidable agents of the power of the seas on the globe."

The above is after all but a fanciful theory; "ground swells" exist in truth, and they form the fisherman's warning of the approaching gale; the impress upon the wave being more rapid than the velocity of the wind; but "ground waves" do not exist without being visible upon the surface, and yet Colonel Emy would have us believe that there is a ground wave in motion, when all is quiet above. His ground waves, supposing they existed in very deep water, could only arrive by volcanic agency; and he is wrong also in his inferences as to the occasional increase of bars. If the gallant officer's theory were correct, we should find all rivers barred up; shut up during the long continuance of on-shore gales, and the shore itself would receive vast accretions of sand or shingle; but this is not what really occurs in nature, because the usual effect of on-shore gales is to remove detritus seaward; to wear away shores; to sweep off and carry seaward the sand hills which border many sea shores. The wreck which is thrown upon the coast is of lighter materials, which, floating on the surface of the waves, receives the additional influence of the action of the wind; but even such materials are frequently carried out to sea; the fact is, that during the prevalence of on-shore gales, the level of the sea on the shore is raised greatly above the usual difference between the rise of tide on the shore, and that in the offing, or the power of the back-sweep of the wave is thus augmented, and from this cause arises the removal seaward of the detritus from the cliffs or banks which had been broken up by tempestuous waves.

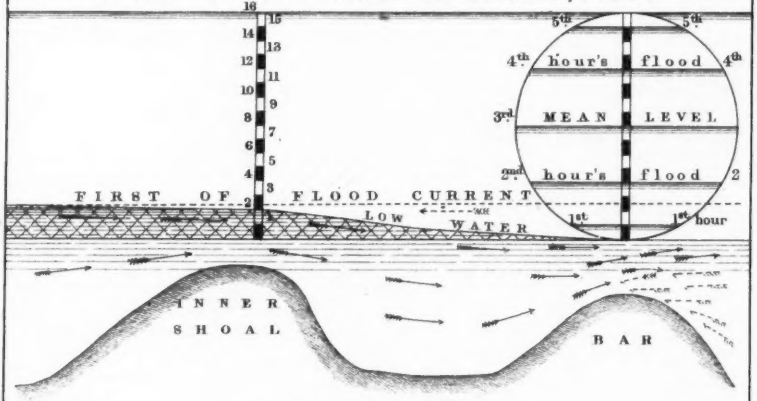
The only part of Colonel Emy's description which, in my humble opinion, is sound, is where he pictures a river forming a junction with the sea by means of its waters being diffused in an estuary, the bed of which forms an inclined plane, gradually uniting with that of the bed of the sea; such, in fact, as we observe in the Humber and all rivers free from sea bars. The Humber from the shelter, which it derives from Spurn Point, would not, however, allow Colonel Emy's "flots de fond" to enter, if such existed in nature.

A much clearer perception of the cause of bars was expressed in some of the questions and replies during the sitting of the Royal Commission on Refuge Harbours, which were to the effect, that bars owed generally their existence to the pent-up back water of rivers coming into confliction with the current of the early flood-tide.

If Colonel Emy had treated on "ground currents" instead of "ground waves" being the cause of the formation of bars, he would



LEVEL OF HIGH WATER OF SPRING TIDES



Horizontal Scale 2 Inch^s to 1 Mile.
Vertical Scale 1/18th of an Inch to a Foot.

J.R.Jobbins.

not have been placed in the difficulty of having to account for the presence of bars at the mouths of rivers varying for months and years together only a few inches in depth of water on them, during both long calms and on-shore gales. The accompanying diagram, or tidal section of the Tyne (plate xx), will be found to elucidate the nature of the confliction between the early flood current and the backwater of the river, the strong black line on the section representing the actual slope of the river surface at the instant of first of flood on the bar during spring-tides, and the lower line that of the lowest level to which the river falls. The dotted line shows the height to which the tide in the example before us had risen at the mouth of the harbour before any sensible current of the flood took place; and, therefore, defines the extent of the duration of the confliction on the bar between the latter portion of the ebb and early flood-tide. That that conflict between the latter division of the ebbing waters of a bar river and the early flood-tide does take place in every case where bars exist may be readily verified by using a float of nearly the same specific gravity as pure sea-water; placed in the tidal current which supplies the river, it will, on meeting with the lighter water of the river, sink through it to the heavier stratum of sea-water which still holds its course to the bar, until it there becomes stagnant on encountering the stronger current of the yet ebbing water of the river.

It has been advanced that backwater has an injurious effect at the mouths of harbours by causing the existence of bars; but this objection only holds good against that portion of it which is discharged into the sea while the tide is making there, and it has been justly urged that the additional velocity of the ebbing waters of a river renders the latter more difficult to make for refuge, than in the case of a harbour which consists only of a tidal inlet or reservoir.

Many of the members of this Institution have opportunities afforded to them, while engaged in their professional duties, of testing the accuracy of the author's theory of the cause of the existence of bars, published in 1841, and already explained in the preceding pages. A single day's tidal observation, when there happens to be a clean ebb at sea, while, at the same time, the river is free from the presence of an excess of backwater or land floods, will determine at once the question whether there exists any confliction between the flood and ebb currents, the extent of which will be measured by the diminished range of tide within the river, and attendant preponderance of the duration of the ebbing current over that of the flood-tide.

This theory applies solely to tidal rivers, or to the cause of the existence at the mouths of bars, properly so called, as distinguished from the irregular deposits which take place at the mouths of rivers which discharge their turbid waters into tideless seas; which latter will subsequently be treated upon in this memoir.

Where this feature exists of a great slope or sharp fall of the surface of the river, as observed at the instant of first of flood at sea, with a consequent rapid loss of tidal range at a short distance from the mouth of the river, a bar is sure to be found, unless the discharge takes place where there happens to be present a strong littoral current,

which exceeds in velocity that of the current of the river where its waters debouche into it. This exception will, however, be seldom found where the discharge takes places into an open sea, although it may exist where a river is discharged into a strait, or into an estuary like the Bristol Channel, through portions of which the littoral current ranges with a velocity greatly exceeding that of some of the minor streams which discharge their waters into it. As examples of rivers whose bars are due to the feature of a great loss of tidal range at a short distance from their mouths, the author of this paper has previously quoted the Esk, Tees, Wear, Tyne, Aln, Tweed, Lune, Wyre, Mersey, Dee, Liffey, Ballyshannon, the Ouze (Lynn), Nene, Welland, Witham, Exe (Exmouth), Poole, Salcombe. In some cases this feature has been increased by the construction of bridges with massive piers, such as that across the Tweed, which diminishes the tidal range as much as three feet in little more than the course of a mile of the length of the channel, near the mouth of the river.

It is too much the usage of some engineers, whose minds have not been given to the study of the tidal phenomena of rivers, to attempt to mystify the treatment which rivers should receive for their improvement, by promulgating the doctrine that each river should be considered *per se*, and that the evils which they are called upon to remedy require an especial specific, or nostrum, from the hands of the professional operator, as if the causes which produce shoals in the smaller rivers above-named did not produce precisely the same effects in others on a grander scale.

To show, however, that the same causes affects the larger as well as the inconsiderable rivers above described, we have but to refer to the mighty Indus, whose waters are also discharged into a sea having a tidal range of from ten to twelve feet during spring-tides, and this we are enabled readily to do by referring to the following extracts from the memoir by Lieutenant Careless of the Indian navy, as published in the Transactions of the Royal Geographical Society in 1838, which memoir clearly proves that to this feature of a great fall of the low water surface, or rapid loss of tidal range, is to be attributed the fact of that otherwise noble river not being in point of navigable qualities for sea-going vessels equal to the most insignificant or smallest of the bar harbours on our own coasts.

Lieutenant Careless tells us that "between the eastern and western mouths of the Indus the sea-coast of the Delta runs nearly in a straight direction to the north-west for about 125 miles; the shore is low and flat throughout, and, at high tide, overflowed to a considerable distance inland."

"A broad alluvial bank, projecting everywhere from the coast, extends from the Bay of Kurrachee to the north-west extremity of Kach, and, in width, varies considerably."

The Indus, like the Danube and Mississippi, discharges its waters through many channels, but it will be enough to describe the features of one of them, viz., the Kúkéwari. Of the Kúkéwari Lieutenant Careless says, "Outside the sea rises ten feet on the springs, but this quickly decreases on the bank to six, and at the mouth of the river to

five feet." "At the lowest state of the tide, the central parts of the bank are elevated twelve feet above the level of the sea, and the beds of the two southern channels from three to four; the vast body of water issuing from the main river rushes through them with great impetuosity, and with a noise that, in calm weather, is heard some distance; they then form what may be termed rapids, and on the extreme edge of the bank, terminate in a fall of about twelve inches." Again, "The flood does not ascend the main river higher than Anni, a village ten miles from its mouth, nor even to this distance on the neaps; but the influence of the ocean tides is perceptible as high as Titiyah, where there is a mean daily rise and fall of four inches. The velocity of the flood varies in different places, but never exceeds a mile an hour, nor does it continue to flow longer than two or at the most three hours."

The mighty Indus, from such defects, is therefore only capable of being safely navigated by sea-going ships of a draught of about eight feet, whereas, if even one of its numerous outlets were trained so as to have its waters discharged in a single channel, by a pier forming a segment of a large circle extending over the outlying bank, so that the current would be certain of maintaining a permanent and uniform course along the concave side of the pier, the Indus would not have less than four fathoms at low water, and at high water of springs about six fathoms available depth of channel. "Surely, such a work would be worthy the genius of an enlightened people, and a certain source of wealth and prosperity." Railroad communications may be destroyed by an insurgent population, but the great natural highways of India—her rivers—afford the certain means, if attended to, of enabling a comparatively small force to command vast districts, in a military as well as in a commercial point of view.

But to revert to the physical features of the channels and tidal phenomena of the Indus. It is clear, from Lieutenant Careless's description, that long after the tide has made at sea the backwater is rushing out, and that at the very mouth of the river a confliction takes place between the flood and ebb tidal currents. At the verge of the bank there is shown to be an overfall, or rapid, of twelve inches, and across the outlying bank to the mainland, a distance of about five miles, there is a further loss of tidal range of five feet. Hence, at what is commonly called the mouth of the river, the tidal range is only about one-half of what it has at sea, and the duration of the flood is justly described as being only of from two to three hours, instead of about six hours.

From the same excellent authority we learn that in 1838 the easternmost outlet of the waters of the Indus, called the Kori mouth, exhibited some physical peculiarities not observable in the other channels through the delta of the Indus, and that through the bank or bar at the Kori, there existed two broad and deep channels, having, on the shallowest part, or bar, twenty feet in depth at low water.

We also learn, that at the Kori mouth of the river, the range during spring tides is thirteen feet, and that at Kotasir, a town situated on the left bank of the river, at a distance of thirty-two miles from the

bar, the range is ten feet; and further, that at Lakh'pat, sixty miles from the mouth of the river, it is even there as much as four feet. These interesting details by Lieutenant Careless at once account why there existed, at the Kori mouth, a valuable deep-water navigation as contrasted with the other shallow outlets of the Indus. In the thirty miles of channel between the bar and Kotasir, the declination of the surface at low water only amounted to three feet, or the fall, estimated from the level of extreme low water at each place, amounted to little more than one inch per mile, whereas, at the other channels of the Indus, the fall was found to be at the rate of twelve inches per mile.

From the above observations, a correction has to be made to find the true fall of the channels at the same instant of time, or of low water, or first of flood at sea, in order to determine the degree of opposition made by the pent-up land waters to the ingress of the young flood.

At the Kori channel there was evidently very little opposition or confliction between the last of the ebb and early flood tide. To what circumstances are we then to attribute this extraordinary advantage of the Kori over the other channels of the Indus (the channel at Kurrachee excepted) is the next subject for consideration; and here again the great value of Lieutenant Careless's communication is apparent, to prevent us falling into the error of imagining that a channel like that of the Kori can enjoy *permanent* deep water without the aid of the backwater, or drainage of the country. That gentleman tells us that the Kori had nearly altogether ceased to be a channel for carrying off the floods of the Indus, and that, in point of fact, it was, when he surveyed it, almost a pure tidal estuary or inlet. He says "That the Kori which separates Sind from Kach'h once formed the lower part of the Feleili, and it also received the waters of a large branch thrown off by the main river, during the inundation, near B'hkur; the beds of both of these branches are now partially filled up throughout the whole of their course, and the portion of water they receive during the swell is prevented from passing into the Kori by bands (dams) that have been thrown across them by the Sindians."

That permanent good effects have not followed this Sindian engineering of turning the backwater from its ancient course down the channel of the Kori, will be found by reference to the survey made by Lieutenants Grieve and Ward in 1848-1850, from which it appears that the available depth of twenty feet on the bar of the Kori, as found by Lieutenant Careless, had at that time already decreased to only nine feet at low water; and we may rest assured that, deprived of its backwater, the Kori will gradually fill up, or be reduced to an insignificant drainage of the adjacent district.

The harbour of Kurrachee, which has two and a-half fathoms at low water, forms the westernmost of the former outlets of the Indus, and, like the Kori, receives at present little of the waters of the Indus, while the latter is in a flooded state; the Gorah channel, which formerly carried the floods to Kurrachee, being now nearly deserted or dry. It is evident that the continuance of the present navigable ad-

vantages at Kurrachee must be considered to be very precarious. To the Indus in its present condition there is no chance of the "do nothing policy" of "letting well alone," as it is improperly called, being judiciously applied, for Lieutenant Careless truly observes, "Of one thing, however, we may be assured, the Indus can scarcely be in a worse state at its mouths than it is at present; and any change must be for the better."

The coast line of the delta of the Indus trends from north-west to south-east, and is subject to heavy seas during the south-west monsoon. The outlying banks frequently rise nearly abruptly from a depth of two and three fathoms, very different from the condition of the banks forming at the head of the Bay of Bengal. The tides set to the east-south-east on great part of the coast, and sufficiently strong to carry the *alluvia* brought by the stream clear of a properly directed outlet for the waters of the Indus, and any further extension of pier works would be succeeded by the creation of valuable land.

If the currents through the sea-reaches of the various outlets of the Indus were trained by the formation of breastworks through the outlying sandbanks, concave to the action of the ebbing waters, their beds would be depressed by the first flood, and attended with a depression of the low-water surface to an extent which would allow the free influx of the tide. The channel, no longer nearly altogether confined to the capacity due to the discharge of the land-floods or backwater, would experience that augmentation of dimensions which is due to tidal influence where it penetrates far inland; as we see in the channels through the delta of the Ganges, many of which possess great navigable advantages, which are at present denied to those of the Indus.

Charts of the deltas of the Indus and Ganges illustrate the different conditions of the discharge of the vast volume of waters of those rivers. The main distinction between the Indus and the Hoogly, Ganges or Burrampoota, or cause of the superiority of the navigable facilities offered by the two latter, is to be found in the small slope of the sea-reaches. In the Hoogly an increased range of tide up the channel takes place, as opposed to the rapid loss of it in the Indus.

It is thus that we find no sea bar at the eastern or great outlet of the Ganges, Burrampoota, and Mutla, the soundings gradually shoaling from ten to five fathoms at low water.

At their entrances the normal flood currents take nearly the same course up the channel as those of the ebbing waters, and therefore there is no loss of depth, such as takes place at the mouth of the Hoogly, owing to the normal flood current there having a different course from that of the ebb, as will be apparent on an examination of the chart before you.

Thus the eastern channel into the Hoogly, which is generally used, is formed by the normal current of the flood tide, and carries a depth of above six fathoms at low water until that current becomes checked by falling within the influence of the eddy created by the deflection of the current of the ebb on striking against the north shore of Saugor Island above Mud Point.

In that eddied tide, lands and shoals are rapidly forming, and over the latter at a slack called "Lloyd's Channel," ships are obliged to pass, in order to get into the *middle channel*. This latter channel which is, like the eastern, due to the normal current of the flood tide, suffers at its upper end in like manner to the eastern channel, a reduction of its depth on encountering an eddy made by the deflection of the ebb tide on the passage of the latter past Diamond Point, and ships are therefore again compelled to pass over the shoal created by it in order to get into the deep channel of the ebb tide above Mud Point; the course to reach the latter being through Mud Point Channel which has three fathoms in it at low water; whereas in the channel of the ebb there is a depth of five fathoms.

At the Hoogly there is, therefore, no true sea-bar, such as is found at what are properly called bar rivers, and that river would possess the same advantages as the outlets of the Ganges, or Burrampoota, if the currents of the flood and ebb tides were trained to follow the same course. For want of this the available depth into the Hoogly in its ordinary state is barely three fathoms at low water, and attended by circuitous channels; and this defect has led to the recent establishment of a new port on the right bank of the adjoining River Mutla, which carries, by an easy sailing course, the full depth of five fathoms, up to the quay forming the terminus of the new railway between Calcutta and the Mutla.

The most recent survey of the Hoogly, by Mr. A. Bedford, in 1854, between Kulpee and the Gaspar Light, strongly illustrates the evil consequences of the flood and ebb currents being allowed to occupy different channels. The ancient lighted and beaconed track by the eastern channel will evidently be soon lost altogether, the available depth from Saugor roads to the western channel through the passage called Lloyd's Channel, being only two fathoms in lieu of three fathoms at low water, as per previous survey; and the shoal ground is now found to extend over more than three-fourths of the river abreast of Saugor Island.

Having shown that the bars of tidal rivers are created by the obstruction offered by the pent-up backwater to the free entrance of the flood-tide, it remains to draw the distinction which exists between them and the bars which are sometimes met with at the entrances, or outlying the entrances, of pure tidal inlets, or where the amount of drainage, or natural backwater, is too insignificant to have any material influence upon their features.

As a rule, it may be trusted that the cause of the existence of bars or banks at such harbours, is due to the heaving up of travelling sand or shingle along the coast by the action of the surf or prevailing gales, and that in rivers which have bars from the cause beforementioned, they are aggravated by the presence of travelling shingle; further, that there is a freedom from such obstructions, solely where they are protected from this travelling of shingle along the coast by some shelter from outlying land, and also where the harbour is located upon a deep water or bold foreshore.

Another feature of a tidal estuary or harbour free from the presence

of a bar, is where the outlet is found exposed to a strong transverse current.

As familiar examples of the effects of travelling beach in choking up or barring the outlets of tidal harbours, it will be enough to refer to Pagham, Chichester, and Langston Harbours, on the coast of Hampshire. Chichester, as a tidal reservoir or harbour, is considerably larger than Portsmouth harbour, yet Chichester has only two feet on its bar, and Langston harbour no more, while Portsmouth has on its sea-bar four fathoms at least at lower water. Chichester and Langston harbours are exposed to the drift of shingle from south-east gales, the accumulation of which is yearly adding land to the coast-line; and further, the debouching waters from those harbours are paralysed in the feeble coast-tide of the bay, abreast of their mouths. Between Langston harbour and Southsea Castle there is little accumulation of shingle on the beach, because the south-east surf feels at Langston a diminution of its impulsive power on encountering the effluent waters of that harbour, and the accretion or deposit of shingle lies further out on the Horse sand; which latter, since the time of Collins's survey,has increased in area and height, and has the useful effect of confining the effluent waters of Portsmouth harbour, of which the Horse sand forms the left bank of the sea-reach, and thus brings the site of Portsmouth bar within the range of a stronger tide than is found abreast of Langston and Chichester harbours; and hence the cause of Portsmouth having four fathoms on its sea-bar, while Langston and Chichester have only one-third of a fathom at low water.

It has been advanced, that cases occur of rivers which are free from bars, although the feature is presented at them, of a considerable slope of the low-water surface in the sea-reach, but this can only occur where the discharge takes place in a strait or channel subject to the scouring influence of a much more rapid tide than that of the channel, whose waters may debouche into it. Thus some of the streams which are discharged into the estuary of the Severn or Bristol Channel will be found free from bars, while others situated out of the sweep of the strong current of the Bristol Channel will be found encumbered with them.

Milford Haven, Cork Harbour, Vigo Bay, and Falmouth, will be remembered as familiar examples of tidal estuaries on bold lines of coast not subject to the influence of a travelling beach, and, therefore, free from bars.

The last description of bar rivers remaining to be noticed, consists of those whose waters debouche into tideless and nearly tideless seas; or where the only alteration of their level is produced by the long prevalence of winds, such as those from the north, which, blowing for several months together upon the coast of Egypt, raise the surface of the Mediterranean there about eighteen inches above its level at other times.

These rivers differ greatly in their features from tidal rivers. They experience little enlargement of their channels as they approach the sea, beyond an increase of the hydraulic mean-depth, consequent

upon the diminished slope of the bed. The main channel becomes, in fact, reduced by the bifurcations which take place; as we see at the Danube, Nile, and Mississippi, consequent upon the lengthening of their channels by the deposit of alluvia; the operation of nature being that of storing up the source of future means of producing food. The bifurcations which take place are nothing more than the results of efforts of the stream to escape where it meets with least resistance; and, therefore, when by accidental or artificial measures, one of the channels attains a greatly increased length, of course, and consequent diminished slope and velocity of its current, it will, as aforesaid, break through its banks with the first extraordinary flood, and find a shorter course to sea. It is thus that we see Providence raising to the hand of man the fertile plain, and the on-shore gales are compelled by the same directing power to join in the useful work, and yield back the fertile alluvia, which are discharged into the sea. The coarser detritus of gravel and sand is invariably shown to be arranged by the agency of the tempest to form the lower strata, and the lighter alluvium that of the upper or fertile stratum of the Delta.

This apparent digression is made in order to submit the opinion that we shall be found warring against the course of nature wherever we seek to elongate artificially, to any great extent, one of the outlets for the discharge of the flood-waters of rivers, such as the Nile, Danube, or Mississippi. The great lagoons which are met with in the deltas of such rivers as the Nile, Danube, and Mississippi, appear to have been left as a result of the too rapid elongation of the main channels of those rivers. This effect is easily traced by a study of the course of those rivers through their deltas. With the progress of civilisation on their banks, there has naturally arisen the desire to retain the navigable channel close to the towns built upon those banks. Embankments made to effect this object have necessarily had the the effect of forcing into deep water the alluvia borne by the stream; and thus we see that in later ages the channels have been lengthened or protruded into the sea without sufficient time having elapsed for the production of alluvia to uniformly complete that regular formation of the alluvial tract of land which nature effects when uninterfered with. Without leaving our own shores, we may see how this has been carried out in our own fen districts, and in fact the filling up of the great basin of the Thames.

Where this excessive elongation of the channels of rivers takes place, as we see in those of the Mississippi (see plate) and the Nile, the alluvia are at first forced into deep water, but, on the occurrence of on-shore gales, they are again thrown up in long banks nearly parallel to the shore, such as those which form the northern enclosures of Lake Brulos on the east side of the Rosetta branch of the Nile, and Lake Menzaleh to the east of the Damietta branch.

On that shore the extent of backsweep is not so great as where the sea is subject to a great lift of tide, and the accretion of land is facilitated.

Although the Nile has at present only two principal channels for

the discharge of its waters, it had many other outlets in former ages, the evidence of which is still visible to attest the truth of the records handed down; and to the sandbanks thrown up from their mouths is probably due the enclosure of the other coast-lagoons of Egypt, as per examples, those which have been in ancient times brought down by the Pelusiac outlet of the Nile, near the west side of Lake Sirbon.

The deltas of the Danube and Mississippi contain vast lakes of the same description, and although, at the mouths of such rivers we may get additional depth of water by concentrating the discharge of several channels into a single one, we shall not get clear of the attendant evil of an increased deposit of alluvium outside, or formation of banks barring up the approach to the channel; and we cannot, therefore, reasonably expect to enjoy, from such rivers, what are considered deep-water outlets for ships of large draught or tonnage, such as are necessary to develope the trading resources of the communities on the banks of the great rivers Mississippi, Missouri, and other tributary streams.

The time appears near at hand when this want must be supplied, but it will be effected only by the formation of a coast-harbour, either on the right or left bank of the Mississippi, in West Bay, in the one case, or in Bay Ronde in the other (vide plate); the requisite shelter for ships being easily to be procured, either by the erection of screw-pile piers, or by training the channel of the south-west pass for the one site, or that of the Pas à Loutre for the other, in order to completely effect that object. Thus, supposing the south-west pass were extended even only two additional miles in the course which it is now taking, sheltered deep water would be obtained over many square miles of good anchorage ground, which might be made permanent for ages by subsequently closing up the south-west pass, or channel, at its inner or northern end, thus forcing the discharge through the other channels to the eastward, and depositing the alluvia of the Mississippi from fifteen to twenty-five miles distant from the new harbour.

The opening out of one or more channels through the narrow belt which forms the left bank of the Mississippi, would certainly secure this object of keeping the harbour clear of the deposit of the alluvial matter borne down by the Mississippi. For the passage of river-craft to the harbour a canal, provided with a lock, or basin, to regulate their transfer when the river is in a flooded state, could be readily constructed.

This deep-water harbour, projected by the author of this paper, would, in fact, be to the vast trade of the Mississippi, and its tributary streams, what the port of Alexandria is to that of the valley of the Nile, and this would be effected without compromising the depth of water in the natural outlets of the Mississippi, which, however, limits their being made use of only by vessels of small draught of water.

It is to be remembered that the Mississippi discharges its waters into the Gulf of Mexico, where there is no passing tide, as may be seen by comparing the times of high water at different places on the coast; and, therefore, there does not exist, for the proposed coast-harbour,

that difficulty in getting rid of the embarrassing effect of the deposit of alluvia, which is so strongly felt, from the influence of the shore-currents, in the neighbourhood of the outlets of the Danube and the Nile.

In the Mississippi, spring-tides rise only eighteen inches.

There we have an example of the hand of man at work, contrary to the process by which nature, when left to herself, creates new land or deltas out of the alluvia borne seaward by mighty streams. In this river there is a protrusion of its channels into the Gulf of Mexico, to an extraordinary extent in advance of the general formation of land, the channels being, in many cases, merely fringed with solid land, an effect which, if not produced, has at all events been greatly increased, by the recent vast forest clearings brought down by the waters in their flooded state.

That the immense volume of the backwater of the Mississippi is only able at present to maintain an available depth of from 8 to 12 feet on its bars, can only be attributed to the numerous subdivisions of its waters, and to the rapid protrusion of the banks which confine them, owing to the deposit of the clearings before alluded to, as well as by the thousands of trees from the undermined banks which are hurried seaward by the Mississippi and its tributaries, by the frequent changes of the course of those rivers. One of the outlets of the flood-waters of the Mississippi is by the channel of the Alchafalia, which reaches the Gulf of Mexico in Chafalia Bay, 150 miles seaward of the Mississippi. An historian of Louisiana tells us, that the Alchafalia leaves the Mississippi about three miles below Red River, that it is nearly 200 yards wide, and has a depth of 18 feet when the river is low, and of 33 feet when in a flooded state. It flows with extreme rapidity when the Mississippi is in a state of flood, but, at other times, the river becomes stagnant for its whole length, and near its mouth it is choked with timber, brought down during the periodical floods. This extraordinary phenomenon in this and other rivers of Louisiana, is known under the name of "the raft." This accumulation of timber extends, on the Chafalia, for 20 miles, in 10 of which the stream is completely choked up.

That there has been a recent great loss of the navigable capabilities of the Mississippi for seaborne vessels is manifest, because according to Malte Brun, its principal mouth had in 1772 a depth of 25 feet, which was reduced to 20 feet in 1767, and to 16 feet in 1826. Captain Basil Hall also mentions that in 1828 it had only 15 feet. The most recent survey gives, however, only 12 feet on the bar of the principal outlet, and at four of the other outlets only from 7 to 8 feet. From the above we must conclude that in the case of the treatment for the improvement of the bars or banks at the mouths of rivers discharged into tideless seas, we have to contend against a land formation which must go on, and that by protruding piers into deep water in advance of the natural progress of the deposit of alluvia, we shall be found to be carrying out works similar to the great but silent process at the mouths of the Mississippi. We shall also mislead ourselves and others by believing that by the protrusion of piers of great length we

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J. Arrowsmith.

shall outrun the deposit of alluvia, and retain the depth proposed to be reached by the pier-heads, or that nature will accommodate us by consenting to store up those alluvia in the dead angles between the pier and the shore, in lieu of also forming banks with them where we require freedom from bars.

Thus at the Sulina mouth of the Danube (plate xxi), a pier has recently been constructed, but already a vast deposit of alluvium has taken place in advance of it on the right bank of the river, to which it has been carried by the agency of the shore current, which there sets from north to south across that outlet of the Danube.*

Notwithstanding the very great improvement in the available depth which has been obtained by the piers at the Sulina mouth, it can be but temporary, because a new bar is already forming further out. By this natural deposit of the alluvia brought down by that outlet, added to those brought by the littoral current from the many mouths of the Kilia branch of the Danube, the deposit seaward of the pier-heads will so lengthen the channel that the stream will, in all probability, break through the left bank near the northern pier-head, and form a new bifurcation, taking a direct and shorter course to the deep water of the northern bay, and the channel now used will be deserted.

The outlet by the St. George's Channel held out the prospect of a longer duration of improved navigation, because, from the trend of the coast-line to the south-west from the right bank, the prevailing set of the littoral current would have carried the alluvia more clear of the immediate vicinity of the pier-heads. This opinion was expressed very forcibly by Captain Spratt, R.N., who had surveyed and attentively studied all the features of the coast and currents, and who, in his able communication to the Admiralty on the subject, proposed also a plan for a southern pier, which, so far as it extends, I do not think could be improved on. I believe that it would realize all that is required, without the aid of the northern pier, which he likewise projected. This southern pier is shown on the accompanying diagram. There is every reason to believe that the talented engineer who executed the works at the Sulina mouth, would also have preferred to execute those at the St. George mouth.

It is also a matter of regret that the lucid reports by Captain Spratt on the channels of the Nile and the phenomena connected with the currents on the northern shore of the delta of the Nile, were not better studied by the international engineers before they committed themselves by signing their report, recommending the construction of the Isthmus of Suez canal and ports, because there is no doubt that, in the words of Captain Spratt, "they will discover, when too late to amend it, that Alexander the Great was wiser than M. de Lesseps admits, when he listened to the local opinion regarding the influence of the Nile upon his harbour, if formed to the eastward of it." Hitherto Alexander has generally been known only as a great warrior, but the

* For the above illustration the Institution is indebted to the Council of the Royal Geographical Society for the use of one of their plates illustrating a paper on the Danube, by Major Stokes, R.E.—Ed.

time will come when credit will be given to his memory for possessing a mind bent upon and capable of realising great and useful works of peace. We know that he perished of a fever caught in the Lamlum marshes, while occupied with views for the improvement of the navigation of the Euphrates, which he evidently considered to be the true route to the east.

That communication to the east, shortening the road by 1,400 miles, will, however, be now executed by a railway, notwithstanding an outlay of millions in attempting to force the trade over or through the Isthmus of Suez.

Evening Meeting.

Monday, 2nd February, 1863.

REAR-ADMIRAL R. COLLINSON, C.B., in the Chair.

ON STEERING STEAM AND OTHER VESSELS.

BY COMMANDER F. P. WARREN, R.N.

IT is undeniable that the great length of modern ships (combined with the daily increasing necessity for rapid manœuvring), calls for some means of guiding their movements with greater ease and certainty than those afforded by the ordinary stern-rudder.

Reasoning by analogy, it is also evident that the attempt to control the movements of these lengthy vessels from one end alone, is wrong in principle, as shown by the manner in which nature effects a similar object. In doing this, however, we must not take aquatic birds as our example, as in their case the body is comparatively short, and is, moreover, provided with *two* propellers of considerable length, and so situated, as to enable the creature, by working either one or both, as required, to regulate and control its movements with the greatest ease and certainty. It will, therefore, evidently be more correct to compare modern vessels with certain species of long-bodied fish. These, it is true, have their principal means of steering, namely, the tail, situated in a position somewhat similar to that of the stern rudder in ships; but here it will be found that the similarity ends, inasmuch as the body of the fish is flexible, and capable of accommodating its curves to the directions in which the creature desires to move, while that of the ship is entirely rigid, and incapable of any change of form, tending to assist the action of the rudder.

It is evident (from the numerous and insurmountable practical diffi-

culties such a construction would involve) that we cannot for a moment entertain the idea of making the body of a vessel capable of curvilinear movements, similar to those of a fish. But although such is the case, there is nothing to prevent the employment of a rudder at the forward as well as the after end, thus to some extent approximating to the perfection of nature, and giving a facility of control entirely unattainable where the ordinary stern-rudder only is employed. By this means, it is obvious that the vessel will be caused, in turning, to describe a circle of very much smaller diameter than if a single stern rudder only were employed.

A well known cause of difficulty in steering screw-steamers, arises from the action of the screw, which, by breaking the current of water, prevents its acting as in sailing-vessels directly upon the rudder. The water thus churned and broken by the action of the screw, loses much of its density, or power of resistance as a steering medium, and is hence greatly reduced in effectiveness. If this is attempted to be overcome simply by an increase of the area of the stern-rudder, it at once becomes necessary to make use of more powerful and complex machinery for actuating it, thereby involving increased liability to strain the stern-post, endangering the rudder-head, weakening the rudder itself, and consequently threatening danger to the ship, and to the lives of those on board.

In the plan now proposed, a safe auxiliary to the rudder astern, is placed in the dead wood of the bow, an arrangement which the fine lines of present vessels, both war and mercantile, renders very easy of adoption; the aperture to receive the bow-rudder being formed abaft the stem, in the same manner as one is now constructed in the dead wood at the stern for the purpose of receiving the screw.

It is scarcely necessary to point out the advantage of having two rudders totally independent of each other, and not liable to be damaged at one and the same time by the same causes of accident; the bow-rudder being merely for use in narrow waters, and on occasions of difficulty and emergency, such as steering through a narrow and tortuous channel—coming suddenly upon a reef or strand—or in thick weather, upon a vessel, which the present rudder alone would not have sufficient stopping or turning power to avoid.

A reference to the inquiries into the loss of steamers, carried out under the direction of the Board of Trade, will show how numerous are the cases of vessels being stranded, owing to the length of time lost in coming round after the danger was seen. In such cases, the additional steering power, and facility of turning or backing off, afforded by the extra rudder would be of vital importance, and would prove the salvation annually of many of our mercantile steamers, and of hundreds of lives.

Again, in a gale of wind, when a steamer can but just head the sea, the stern-rudder would be greatly eased by the bow-rudder's acting to keep the ship's head up, thus enabling an easy helm to be carried, instead of the stern-rudder being jammed hard up to its great danger, and that of the ship. The case of the "Great Eastern" is one in point, and by her narrow escape from foundering when falling off from

the sea, after the accident to her *only* rudder, convincingly proves the necessity for an auxiliary, to which recourse can be had either for assisting the main rudder under peculiar circumstances, or for acting alone, when it, the main rudder, is disabled. Scarcely a week indeed passes that some of our finest merchant steamers are not lost or seriously damaged either owing to the causes here adverted to, or otherwise to the stern-rudder being lifted out of the water, and thus ceasing to act. With two rudders this latter cannot occur so long as the vessel has headway, as when the stern is lifted, the bow is immersed, and *vice versâ*.

In cases of vessels striking the ground, the stern-rudder is frequently lost, and generally damaged; and, in consequence, merchant vessels which under these circumstances, escape total loss, are obliged to go into port requiring extensive repairs, and causing serious, if not ruinous, loss by delay, to owners, shippers and consignees, which, in the case of a vessel fitted with an auxiliary rudder, would be avoided by the vessel being enabled to make a safe passage without incurring the disastrous loss of time, &c., referred to.

The advantage also of having a vessel under perfect command while going astern, can scarcely be overrated. At present, a screw-vessel under such circumstances, is unmanageable; but, fitted with an auxiliary rudder, the largest vessel of this class would be able to leave its port or harbour without having to swing or wait for a tide.

Steam-tugs, so fitted, could, while under stern-way, place themselves under the bows of a vessel with perfect safety and certainty.

To men-of-war it is undeniable, that an auxiliary rudder, entirely protected from shot, must be a great advantage in action: besides which it is to be borne in mind, that vessels of large draught of water, as now fitted, invariably steer much worse in shallow than in deep water, and are, therefore, least manageable at the very time when their immediate answering to the helm is of the most vital importance, as when going into harbour, attacking shore fortifications, &c. The following extract from the *Transactions of the Institution of Naval Architects*, page 139, vol. i, is the opinion of Rear-Admiral George Elliot, Assoc. I. N. A.

> I believe that if a war broke out to-morrow, the commander of the fleet would call out all the paddle steamers as auxiliary vessels; they are serviceable in action in a manner that screws cannot be. *The screw cannot back astern effectively, and cannot run under the bows and take a vessel in tow with the facility of a paddle-wheel.* I therefore think before the paddle-wheel steamer is condemned altogether, as has been the case, one word should be spoken in her favour for war purposes.

The auxiliary rudder, as explained, enables a screw-steamer to carry out in a perfect manner the manœuvres which an officer of Admiral Elliot's experience puts forward as a sufficient reason for pausing ere doing away with a class of vessels which in other respects is obviously far inferior to the screw for war purposes, and would only at best be retained for possessing qualities which it has been shown may be readily and simply given to the screw.

Having concluded these preliminary remarks, I propose in the next place to go into the plans and the reports of the trials that took place;

and perhaps it would be as well to make a few remarks upon points which, theoretically at least, we may take as established facts.

1. If the bow- and stern-rudders be considered as levers of the first order, the bow-rudder would have the same power to pivot or turn the vessel as the stern-rudder if the areas be the same and the centre of displacement equidistant from each, the form of the vessel at either end being identical. The only vessel which we have in our service where an attempt has been made to fit her with a bow-rudder, is the "Weser," built by Mr. Scott Russell for the Prussian Government, and which was exchanged, together with the "Recruit," in 1853 or the beginning of 1854, for one of our frigates. I show here a diagram of this vessel (plate xxii, fig. 1), not with the view of pointing out the defect in the bow-steering power of the bow-rudder of the "Weser" or "Recruit," but simply with the view of showing how far, up to the present time, we have progressed in the way of carrying out the idea of the bow-rudder. Here you see the bow-rudder as fitted to the "Weser." My experience of a rudder so fitted is, that it has no steering power when going ahead. But I am not guided by my own impressions solely, as, having communicated with officers who have commanded this vessel, they tell me that she has no steering power in the bow-rudder going ahead.

I will read an extract from a letter written by an officer who commanded the "Recruit":—

> The bow-rudder was useful in "Recruit." She has often gone out of harbour one end first and come back the opposite way for convenience in taking in moorings. In harbours and in the river Danube it has often been used successfully to prevent the necessity of turning. I could not use it with success in starting from an anchor, or in conjunction with the after-rudder for turning purposes.

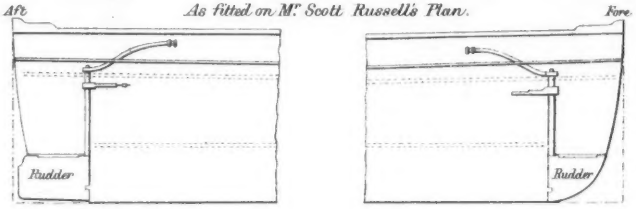
I may here observe, that during the last Chinese war the French gun-boats in the Peiho were fitted with bow-rudders; but they were of the same description as the stern-rudders. I have obtained the opinions of officers who were out there, but every one of them gives me an opinion, so far as I can judge, according to what he thinks the rudders did, for nobody can tell me distinctly how they really acted. No doubt they had full command over the vessel in going astern; but if the bow-rudder in the "Recruit," of which we have perfect data, had no power when going ahead, I cannot see how the French gun-boats could go ahead under command with their bow-rudder. They are fitted on exactly the same principle. They have a spindle outside the stern, and it is the same rudder as that in the "Recruit."

I now come to the trials which have been made with the "Princess Royal" (see fig. 2), and which I may safely say will establish the practicability of this rudder, or the Government would not have adopted it in the "Sharpshooter." The "Princess Royal" is one of the Ryde boats, a vessel of about 110 tons. She was the only vessel I could get, the manager of the Company having kindly allowed the experiment to be tried in her, she being ready for launching from the slip. There was only forty-eight hours to fit her. So that instead of having the rudder placed as I should wish to place it, in the dead wood, as in the "Sharpshooter" (fig. 3), which would have in-

Fig. 1.

Weser.

As fitted on Mr. Scott Russell's Plan.



Sharpshooter.

As fitted on Captain Warren's Plan.

Fig. 3.

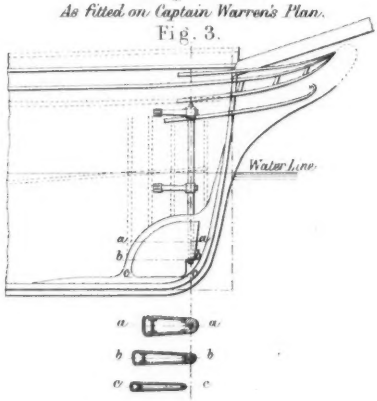


Fig. 3A.

Sections of Ship, shewing the method of securing the Frames to each other by means of wrought Keel Plate.

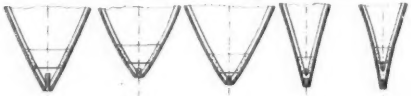
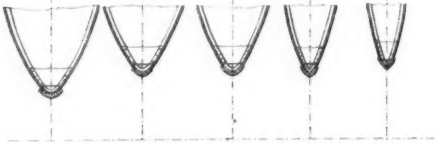
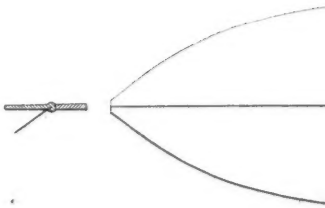
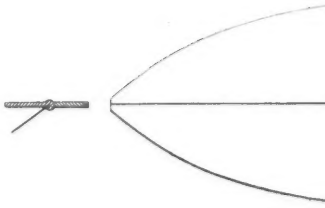


Fig. 3 A.

Sections, shewing the Frames secured to each other by means of a Bilge Plate.







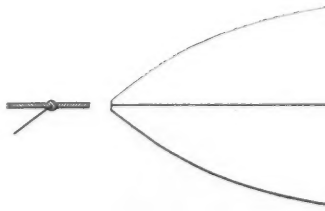
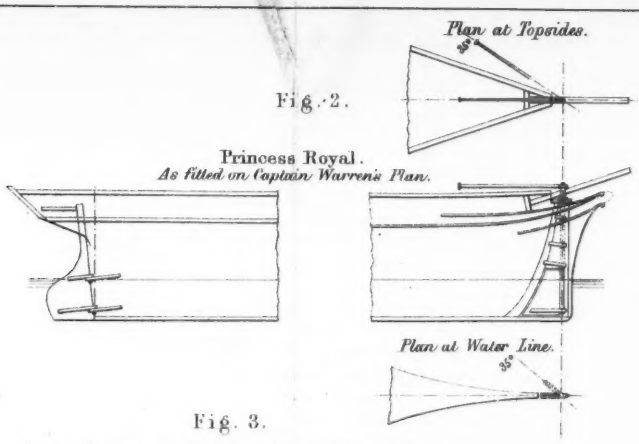


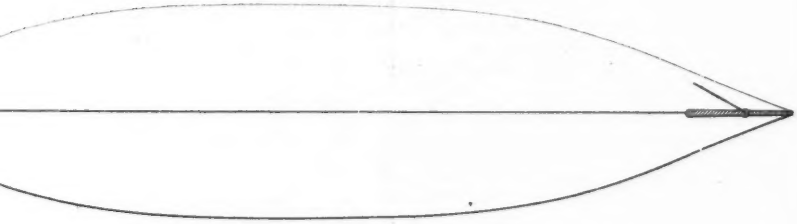
Fig. 2.



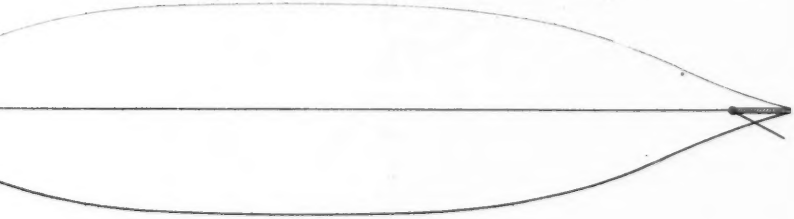
Princess Royal.
As fitted on Captain Warren's Plan.

Fig. 3.

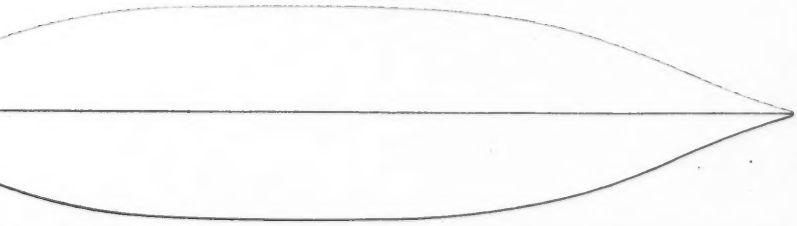
Sharpshooter. *As fitted on Captain Warren's Plan.*



Weser. *As fitted on Mr. Scott Russell's Plan.* Fig. 1.



Plan of ordinary Rudder.



volved a good deal of work, I had the keel lengthened and an additional stem put on. The areas of the bow-rudder to stern-rudder were as 9 to 15 feet. I may here mention, as is well known, that in a paddle steamer when she begins to go ahead the tendency is to draw down by the stern. So that the stern-rudder as fitted in that vessel became more immersed the faster she went, while the bow-rudder was proportionally lifted, losing power. Besides, the narrowness of the stem in this vessel, which I will point out when we get further into the question of fitting, produced a very great disadvantage on the action of the rudder.

I may as well point out that the difference between this and almost all other bow-rudders that have gone before it, is the manner in which it is hung. The spindle is in the after part in every other rudder. I believe there is a rudder that shifts on the stem, fitted in the same manner as mine; I have not seen it, but from the experiments I have tried I cannot conceive that it has any active power in steering a vessel. Another is hung on or in an outer stem, but not in the dead wood as in the "Sharpshooter," which is the point where the power is gained, as the further aft in the vessel's bow the rudder can be placed, the greater the power. When I was fitting my rudder, a great many people who came and looked at it, said they had seen it before, that it was quite common in the Mersey. Upon questioning them further, it turned out, though they said it was exactly the same, that it was quite the reverse.

My bow-rudder is entirely protected from shot. Diagram (fig. 33) shews how it is fitted to the "Sharpshooter." The "Sharpshooter" is a vessel with a light draught of water. If the rudder were fitted to the "Warrior," the men who steered the ship would be from six to eight feet under the water. There would be a lower tiller. You might have three tillers if you chose. And if the upper tiller were shot away, not only the rudder itself but the men who steered the ship by the lower wheel would be completely protected from shot.

Another feature is that the power of steering a ship when going astern is equal to the present rudder when steering a vessel when going ahead. I take this from the report of Captain Coles:—The areas of the two rudders being as 9 feet to 15 feet; the stern-rudder going full speed, head to port, was 3 m. 9 sec.; going at half speed, 3 m. 10 sec. With the bow-rudder alone, at full speed, it was 5 m. 34 sec.; at half speed it was 5 m. 17 sec. This, within a fraction, gives the exact ratio between 9 feet and 15 feet; that is to say, the area of 9 feet bow to 15 feet stern is as 3 m. 9 sec. to 5 m. 34 sec. Going astern the circle was completed with the stern-rudder, at full speed, in 6 m. 56 sec.; at half speed in 6 m. 11 sec. But here the bow-rudder has an immense gain, for at full speed the circle was completed in 4 m. 20 sec., and in 4 m. 20 sec., singularly enough, at half speed. We cannot arrive at any reason for this, but it is the simple fact that there was a difference of 45 sec. between full speed and half speed with the stern-rudder, and no difference at all with the bow.

At first sight, on looking at this model, it would appear that when

the ship is going astern there is an enormous action exerted on the rudder to tear it off its spindle. Practice does not give that result. It has been tried repeatedly. In the "Princess Royal," it is only a temporary thing, and fastened with inch bolts; the gudgeon was one-eighth iron and a simple strap. On one of the trials when going astern, steered by the stern-rudder, at full speed, the rudder got across the ship's stern, and became unmanageable, and the tiller was bent double in trying to right the helm; while on going astern full speed with the bow-rudder, and the rudder being let go hard over, it was righted again by one man; the length of both tillers were the same. One man was able to right the bow-rudder, while three men broke the tiller of the stern-rudder in trying to right it. This, I think, can be accounted for by supposing that the current of water which passes through the aperture, when the rudder is put over, takes away that apparent resistance which you will find with the stern-rudder, when you bring the rudder over at a certain angle, you bring it over against a fixed body, and you are piling the water up against it; in the other case you do not bring it up against any fixed body, you only have the resistance of the water itself.

The next point is the very small area in making the circle when both bow- and stern-rudders are worked together. There were two trials under the superintendence of Captain Coles, and two trials under Captain Broadhead, and at both these trials there was, as near as one could judge without measurement, a reduction of 50 per cent. in describing the circle when both rudders were used in conjunction. The gain of time was small; at the best it was not more than 14 seconds, but the area was reduced 50 per cent. Where you wish to stop a vessel suddenly, there would be great advantages in two rudders, because you would put the bow-rudder over one way and the stern-rudder over the other, and you would have a stopping power at once, the one rudder balancing the other.

I shall now read Captain Broadhead's report of the trial in the "Princess Royal." In this vessel, from some cause or other, which we only found out after she was docked, a difficulty was experienced in making her complete the circle to starboard. It arose from the crookedness of the keel, which had been put on out of the straight; so that she carried, under ordinary circumstances, a strong port helm, and she could not be got round in one way for some time, but at the trial by Captain Coles, and by humouring her, the circle was completed to starboard; that being done, it satisfactorily proved that the rudder acted perfectly, but the fault in steering arose from the malformation of the vessel. This was the opinion of the Government officers.

Trials of Commander Warren's Plan of Steering.

Sir, 24th July, 1862.

In pursuance of instructions communicated in your memoranda of the 19th instant to witness Commander Warren's plan of steering with a bow-rudder as fitted to the "Princess Royal," Ryde Packet, we have to report that we yesterday made the following trials, but must first observe that the vessel is ill-adapted for the purpose,

as from some unexplained cause, probably a bend in the keel, the stem not being perfectly upright, or malformation in the bottom, while the bow-rudder acts readily in turning to port, it is nearly useless in turning to starboard.

1*st Trial.—In Harbour.*—Proceeded from off Dockyard at full speed, through the ships to the entrance of Fareham Lake, above Hardway, where the vessel was turned and taken to Spithead. Throughout the distance she was steered with the bow-rudder, except when making the turn up the harbour, and when avoiding objects on the port side, when it was found the port helm had no effect.

2*nd Trial.—At Spithead.*—With stern-rudder, helm hard astarboard, vessel made circle in	3′ 13″
With bow-rudder placed as above, vessel made circle in	7′ 9″
Gain of stern-rudder over bow	3′ 56″
3*rd Trial.*—With stern-rudder, helm hard aport, vessel turned in	3′ 45″

With bow-rudder placed as above, vessel only turned 8 points in 7 minutes, and would have gone on shore before turning. The attempt to turn her was therefore given up.

4*th Trial.*—Vessel was stopped dead. The helm of bow-rudder was put hard astarboard, vessel made circle in	6′ 54″
5*th Trial.*—With both rudders, vessel made circle to port in	2′ 51″

The small circle in which the vessel turned was very remarkable.

6*th Trial.*—Vessel going astern at full speed, made the circle with after-rudder, helm hard astarboard, in	7′ 29″
Under similar circumstances, with bow-rudder, in	8′ 27″
Gain of stern- over bow-rudder	0′ 58″
7*th Trial.*—Vessel going astern at full speed, helms of both rudders hard aport, vessel made circle in	5′ 0″
Or a gain of stern-rudder only of	2′ 29″

To conclude the trials, the after-rudder was choked when about a mile distant from Ryde Pier, the vessel put at full speed, and the bow-rudder only used, when she steered stern foremost in the most perfect manner, passing through the ships at Spithead up the harbour past the Dockyard, when she was turned without the stern-rudder being touched.

The comparative areas of the bow- with the stern-rudder is as 9 to 24.

From what we have observed we think the bow-rudder to possess about half the power of the after one, when steering ahead, which would doubtless be increased were the area of the two rudders more nearly equalized, to give a fair estimate of its power.

In conclusion it appears to us that the invention is of value, but think it capable of great improvement in its details.

We return herewith Commander Warren's model and papers, and have, &c.,

(Signed) H. Broadhead, Captain in charge of Reserve.
I. Tonkin, Master Attendant.
H. Cradock, Master Shipwright.

I have no doubt many know what nice steerage it requires threading the way amongst the ships in ordinary of Portsmouth Harbour.

We now come to the "Sharpshooter." I will now explain the proposed manner of fitting this vessel. Here is a model, and here are the two modes of fitting the rudder which were submitted to the Admiralty. One mode is to fit her without any alteration, as any iron or wood vessel may be fitted. This is done by putting the bow-

rudder in the dead wood, without altering the lines of a fine vessel. Fig. 3 shows the manner of fitting the stem; so that when the vessel's lines are brought in, the ship is not weakened, indeed, the vessel is stronger than before by that inner stem. The inner stem is put in, and if the lines are not intended to be fine, this is the form (fig. 3A); and there is one additional plating all round this part of the vessel. Fig. 3A shows her different sections at these different points.

We come now to the most important point, the question of cost. The "Sharpshooter" will cost something under £200; the maximum will be £200, for altering her. That is, I think, a small sum. I think the rudder might be put into the "Warrior" at a progressive cost, comparing the size of the two vessels; however, I have not calculated the expense of altering her. At any rate, if it can be put into the "Sharpshooter" for something under £200, I think the money question is not likely to prove a difficulty.

Another point of importance is this, viz., that the same order answers for both helms. The order to port or starboard the helm is the order for both rudders, were it otherwise, it would lead to endless confusion.

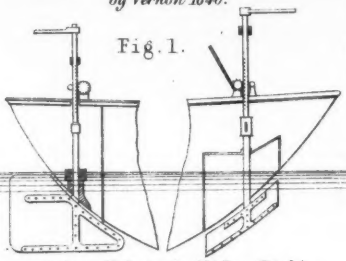
I will now call your attention to the subject of vibration. Up to this time I have only spoken of the rudder as an auxiliary rudder. But I have hopes that this rudder will be able to be used as a main rudder at sea, and this would lessen the vibration of the screw, which we know increases, in a very great degree, directly the helm is put over and piles up the water against the screw. If you steer by your bow-rudder you do away with the increased vibration caused by steering with the after-rudder. Scarcely a month passes that we do not see some of our finest ships returning to port to repair leaks in the stern-post caused by the vibration of the screw.

In conclusion I will deal with the application of the bow-rudder to sailing vessels. So fitted, a sailing vessel has two chances of staying instead of one. If you put your helm down, the vessel comes up head to wind, and then gathers stern-way; you shift your helm and square your yards, and with the stern-way she comes round and answers her helm. It is impossible for a vessel to miss stays, for she can go round as certainly going astern as when she is going ahead. You have constantly seen ships in a calm in a tideway. (The Chairman: I have seen ships in the St. Lawrence rubbing their sides almost through, not being able to get clear of each other.) With a bow-rudder the ships could shear off and take any position they chose.

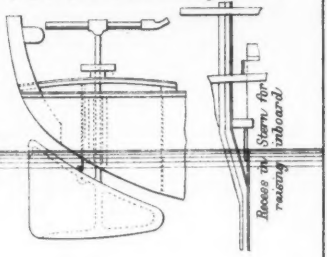
Mr. Chairman and gentlemen, allow me to thank you for the honour you have done me, and the kind and courteous manner in which you have received my remarks on this subject. I feel that I have this evening had an opportunity of bringing the "bow-rudder" to the notice of far more clever and scientific men than myself, and I have no doubt if they will give it their attention, the suggestions of this principle of steering by the "bow," will be carried much farther, and it is with this object that I am here to night.

Original Assam Steamer as fitted by Vernon 1840.

Fig. 1.



Patented Nov.r 1858
And fitted to 4 Steamers and 2 Barges of 1000 Tons each on the Bengal Rivers



Improvements in small Boats after Trials as fitted in Assam Nautilus Flotilla tried on the Thames in 1859.

Fig. 3 *Radial Tow Spar*

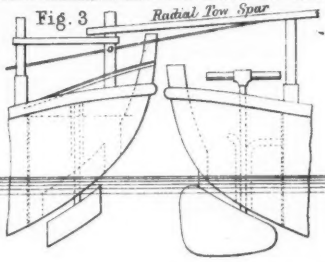
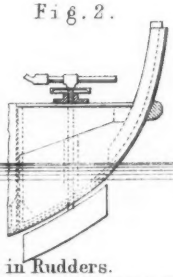


Fig. 2.



Richards's Improvements in Rudders.

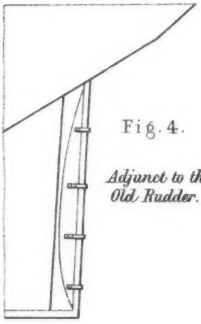


Fig. 4.

Adjunct to the Old Rudder.

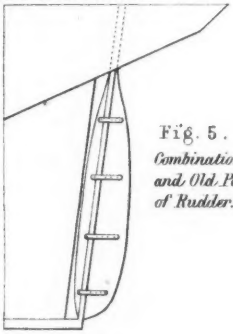
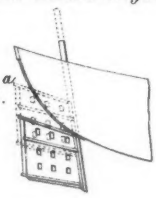


Fig. 5.

Combination of New and Old Portions of Rudder.

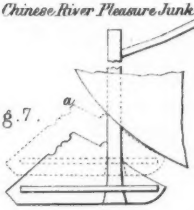
Lorcha or Chinese Trading Boat.

Fig. 6.



Chinese River Pleasure Junk.

Fig. 7.



The Rudders of these Vessels rises upwards to the line a. a. upon coming in contact with any obstruction.

J.R Jobbins

The CHAIRMAN: I have no doubt some gentleman present would like to ask questions, or to offer observations upon this admirable invention of Captain Warren, which I think is likely to be of very great service.

Captain HENDERSON: In 1840 I designed the "Assam" of 400 tons with a bow-rudder, tried her in India for the Assam Company, who kept her going there two years with the bow-rudder in her (Pl. xxiii, fig. 1). That vessel is still in existence. I found, as I dare say you have found, Captain Warren, that there is a great deal of prejudice against bow-rudders. But with this rudder I could turn the vessel within her own length, literally. I adopted the notion from having to build a ship for the navigation of the Burhampooter River. I may mention that I have been connected with steam navigation in India from its very commencement. The first steam vessel built under Lord Bentinck was called the "Burhampooter," and in coming down the river she struck on a quicksand and was lost. The problem I had to solve, was how to get a large steamer to come down the Burhampooter without running that risk, and I hit upon the notion of a bow-rudder. I took the idea from what I had seen of the Chinese tea-junks. They have not a balanced rudder, but they have a moveable rudder, and a large kind of weather-board. I thought something of this kind would be very valuable, but I saw that it would not do exactly for the Burhampooter. All the boats on that river are built egg-shaped, the object being, that should they get ashore or on a shoal, they may "wobble" off again. The vessel I constructed was built partly on the Bengal model, with a bow-rudder, partly like a Chinese tea-boat, and something of the Burmese boat, a combination I call the Assam type, like that on the table before you. I put this vessel together in 1841. She ran about a year and a half on the Burhampooter. While she ran there, I had a good deal of trouble to get a captain to command her, because the rudder was so quick in action that she danced about with it; at last I got one to take her, and he said it acted beautifully and with perfect power. The Assam was then transferred to the Ganges, where there are a great many vessels with the barn-door rudders. She was fitted with a barn-door rudder to her bow, then turned end for end, and her stern was turned into her bow. She made several voyages, but not going satisfactorily, she was turned round again; and there she is to this day with her original bow and stern. She has a peculiar bow, something of a Chinese bow and something of a Bengal bow, a series of cycloidal curves. There is no keel. The rudders are both of them balanced, and they can be made to act as a keel, in the same way as the Chinese do with their rudders. If you look at the model of a Chinese pleasure-junk, in the naval model-room, you will see the balanced rudder (fig. 7). I began by putting one-third of the area before the rudder, and I afterwards increased it to about two-fifths, merely having enough forward to keep the rudder straight.

Commander WARREN: Did you fit them under the keel?

Captain HENDERSON: There is no keel, but a round bottom. I found the bow-rudder fully equal to the stern-rudder. I went on by degrees, and I have in my possession now two tow-vessels 85 feet long, forming, with the "Assam Nautilus," a flotilla. They were fitted with bow and stern rudders. The builder tried them both, and he said the bow-rudder acted equally as well as the stern-rudder.

Commander WARREN: You require a smaller area at the bow than at the stern?

Captain HENDERSON: I did not consider that; I got the area as large as possible. The thing is not to have it below the bottom. The rudders are made self-shifting. They let down and rise up. I may say there are sixteen large vessels of a thousand tons, and twenty-eight small vessels already built in India on that plan, besides the "Assam," which was built twenty years ago.

Commander WARREN: I think if a vessel with those rudders took the ground she would be in an unhappy condition.

Captain HENDERSON: No, the rudders jump up in a moment at both her ends; they were made with that view. I will now read Mr. Mitchell's report of the trial with my rudders:—

"Dear Sir,—I am in receipt of your favour of the 4th June.

"Mr. Rendel has been here during the last day or two, and the weather being fine we have had a run to sea, with trial steamer and barge.

"The result was highly satisfactory as regards towing, we of course towed in the usual manner by ropes, the barge being about 100 feet apart from steamer; draft of steamer 3′ 6″, and of barge 3′ 9″; speed by patent log. 11·57 statute miles per hour.

"We tried experiments with the rudders. The action of the bow-rudder *is very remarkable*, and when used alone has precisely the same action in turning the vessel as the stern-rudder used alone, but when *used together the action is extraordinary.*

"We are now adding sundry details to steamer and barge, and should not like to have another trial for a fortnight.

"I think you will be pleased to know that we steamed from Sunderland (with barge in tow) through Shields harbour and up the river to Walker, full speed, the entire way, both steamer and barge acting admirably.

"To Andrew Henderson, Esq., 32, Gt. Winchester-street." "Yours truly, (Signed) "C. MITCHELL.

He tried it afterwards with Chaplin's patent steering blades. These are two blades which are fitted in the bow and stern by cutting the plates diagonally at an angle of 45 degrees. His report is:—

"Dear Sir,—I am in receipt of your letter of the 13th, and may inform you that the action of your rudder was as follows:—

	Minutes.
"Bow-rudder alone, one revolution of ship	3
"Stern " "	3
"Bow and stern rudder acting together	2
"Chaplin's blade at stern *only half revolution*	3½

"The action of the latter was not satisfactory, and I have now removed it.

"To Andrew Henderson, Esq., 32, Gt. Winchester-street." "Yours truly, (Signed) "C. MITCHELL.

I can quite corroborate what Captain Warren has said with regard to the extraordinary power of the bow-rudder. It is always essential to have it in large vessels, like the "Great Eastern" or the "Warrior." A vessel so very long, in a narrow channel, will have a different action from what she would in deep water. She is never safe; but if she had that bow-rudder she would keep end on. So satisfied was I of the inutility of having vessels for river navigation too long, that when the East India Railway Company proposed to spend £200,000 in steamers and barges, I advised Mr. Rendel that the vessels should not be more than 200 feet in length, and 30 feet in breadth. The matter, however, was left to the option of the contractors, and they decided to make them 225 feet long. The consequence was, they would not go round the creeks of the Delta without great difficulty, but a difficulty which the bow-rudder would obviate. Mr. Rendal then said he would put in a bow-rudder as well as a stern-rudder. The result was, that with the bow-rudder the vessels can get round a point by keeping the bow in the tide. The vessels were however made too long, and the moment he came to try them, were found deficient in strength, and they have been obliged to reduce the whole of the vessels, sixteen in number, by 25 feet. With the vessels that I have built you can do just as you like. We tried one little vessel, and found we could turn her all round the compass in 51 seconds, and turn her up and down channel in 31 seconds. With a large river steamer like the "Assam," I found I could stop her dead in 15 seconds.

I think that the bow-rudder ought to be put not only in steam-ships, but in all sailing vessels. That is what I proposed to do with the "Great Eastern," in 1854. At that time Mr. Scott Russell was at Liverpool, and I proposed that he should put a rudder in the bow, and that he should also put a screw abaft. I proposed that he should have a paddle or screw athwart ships to stand above the screw-shaft; and for that to have an engine, one of Armstrong's accumulators, the object of which is

to produce a pressure of water, so that by turning the water on with a cock, you can back your stern up to starboard. That is still open to the "Great Eastern." I think if you were to give her a bow-rudder, she would be a much more manageable vessel.

But the difficulty I have found is this—the refusal of the Indian Government to have any trials. All the trials have been made here at my own expense. There are two millions or more invested in steam-boats, which ought to have been in operation two years ago, but which are not in operation yet, simply because trials were not allowed here before they sent them out. One set of vessels have had all their engines back to be altered, and there are vessels that have been lying six months, and the contractors will not take them back. There are six that have been in hand four years and a half, and they have not done a day's work yet. Captain Warren seems to have persuaded the Government to make experiments with his rudder.

Captain WARREN: I can only say that I have found the Government very liberal.

Captain HENDERSON: Did they make your vessel?

Captain WARREN: I paid the money and brought it up to a certain point, and then I found the Government aided me. "*Aide-toi*" is the Government motto—help yourself, and then they will help you.

Captain HENDERSON: Did the Government make you a vessel for the rudder?

Captain WARREN: No, I made the vessel myself first, and when their officers certified that the plan was feasible, they put the rudder in another vessel. I think there are other inventors here who stand in precisely the same position; they first of all fitted a vessel at their own expense, and the Admiralty having tested their plans, then tried them at their own expense.

Captain HENDERSON: I was only asking for information. I can only say you have been more fortunate than I have been. I hope you will persevere with your plan, because I believe it will be of national benefit. I do not think any of these large men-of-war steamers can be safely steered without a bow-rudder. Take, for instance, the "Great Eastern" in a gale; she never will be safe without some other appliance than she at present possesses; I do not think she will be safe without something like steam-power to force instantaneously the stern up against the sea.

Commander ARTHUR, R.N.: Captain Warren made a few remarks about the French gun-boats in the Peiho river. I was there at the time, and I may say their bow-rudders were fitted on a projection from the bows. The vessels were put together out there. They answered very well till every one of them was destroyed by running on the banks in the Peiho. Some lasted longer than others, but they were constantly either running foul of vessels, or against the banks.

Captain HENDERSON: Did their rudders project outside the bows?

Commander ARTHUR: They projected outside the bows; the gun-boats were all built of iron.

Captain HENDERSON: I thought they had them protected like mine, and then you could not hurt them.

Commander WARREN: You could not have that plan in an iron vessel.

Captain HENDERSON: Mine is an iron vessel. The additional cost for their protection is a mere trifle; it is not more than the expense of common rudders; mine, however, is not a sea-boat, only a river-boat.

Mr. RICHARDS: After what has been said with reference to ships' rudders, there is but little left to be remarked on the subject. Most persons who are acquainted with naval or military tactics will grant that, next in point of importance to the arming of ships, may be considered their ready guidance or management, and this involves in a great measure the manœuvring of squadrons or fleets. To the effects produced by rapidly-executed evolutions, may be ascribed the final results of many well-contested sea fights, and the advantages of having a "handy ship" were often greater than the disadvantages of carrying fewer guns. Such results, however, were achieved under circumstances more favourable than could be obtained at the present day; for, as the dimensions of ships increased, the difficulty of turning them quickly, or within short spaces, became a serious drawback to their otherwise increased efficiency. The importance therefore attached to steering apparatus, has very naturally attracted the attention of the nautical world, and many and various

have been the devices (and experiments), with a view to increasing the facilities of turning long ships. The old rudder, however, with its admirable simplicity, like the old gun, has kept its place with wonderful tenacity, and it has done such good service, that we should feel reluctant to part with it under almost any circumstances; indeed it requires an effort of the mind to conceive that it ever could be entirely set aside, and it may be presumed that it never will. What it wants is a powerful adjunct, or assistant, and the question should be, which is the best way of accomplishing this object.

By giving a brief sketch of some of the deficiencies in the old rudder (in relation to the increased work which it has to perform in governing the present very long ships), it will be seen more plainly what are the necessary requirements to meet those defects.

In the first place, the stress or wringing force brought to bear upon the rudder-head is such, that the rudder is liable at any moment to become disabled.

2ndly. The tiller is subject to damage, from the great power exerted, or the number of hands required to steer the ship.

3rdly. When a ship has much way through the water, it is found almost impossible to put the helm over to the most effective angle for turning the ship quickly, and thus much *valuable* time is lost—an interval which might imperil the ship.

The requirements, therefore, are—1st. Little strain to be applied to the rudder-head. 2ndly. Inconsiderable power only required on the tiller. 3rdly. The facility of putting the tiller over to the most efficient angle for turning the ship, whatever speed she may have through the water at the time, and this, too, with augmented power in relation to equal areas of rudder.

Now, I find from experiment, that a rudder placed before the stern, or steering-post, has the most powerful properties of steering a vessel with the helm put in the same direction as it would be required, if steering with the old rudder or that now in use. (See plate xxiii, fig. 4.) This rudder will take effect from the time it becomes clear of the dead wood (before it) until it reaches an angle of about 45° (or more) from the keel, but it has its greatest power at about 35°. I should think that for practical purposes 30° formed about the best angle.

This fore-rudder (or adjunct) is of such power, that it will hold in balance an after rudder of nearly three times its area. The proportions ascertained from experiment are about ⅔ths. It will be seen from this, that the power which could be obtained for steering ships is without limit, or only limited by the strength of the stern or rudder-post.

Fig. 5 shows a rudder of the usual size, with the adjunct or assistant attached thereto, in which case the rudder would have about twice the steering power the old rudder would have singly, with the further advantage that the required angle could be immediately obtained, without strain on either the rudder-head or tiller.

In practice any required amount of this power, or leverage, could be adopted; but in all cases it would be judicious to let the after, or old rudder, have the preponderance or governing power.

This system of steering is capable of many modifications, into which it is now unnecessary to enter; but there can be no doubt that the development of the principle would lead to important results in naval tactics.

The CHAIRMAN: Have you, Mr. Richards, made any practical trial of the rudder you propose.

Mr. RICHARDS: The idea first struck me from the application which I saw an Indian make with his paddle over the quarter of his canoe. He kept his paddle perfectly still. The boat had way on her, and by the slightest turn of the paddle it had the effect of turning the boat about from port to starboard. This struck me, and I thought the idea might be applicable to rudders. So I tried it on a small scale first, and it so astonished me with reference to its power of acting in conjunction with the aft-rudder, that I went down to the sea-coast and tried it on a boat. I showed it to some friends and they were as much astonished as I was in the first instance.

Commander WARREN: I am very much obliged to Mr. Richards for what he has said, for every argument he has been using in favour of his stern-rudder is an argu-

ment in favour of my bow-rudder. With respect to the action which he approves of so much, I am afraid he will not find it novel. Lord Stanhope tried it a hundred years ago.

Mr. RICHARDS: I am very much surprised to hear that it has ever been tried: I did not know it was ever in operation.

Commander WARREN: It is the case. I have tried it myself, and I have got a boat now with it, and if you like to go down with me to-morrow I will show it to you. I simply tried it, not with any idea of patenting it, but with the idea of testing its power when the vessel is going astern, and, as you have ably demonstrated it, that is exactly the power it has when the vessel goes astern.

Mr. RICHARDS: It has not the less power because it acts astern. The stern is the very natural place for a rudder. If we can make a rudder sufficiently powerful to do its duty, that is the place for it. As regards the effects of your bow-rudder when the ship is going astern, the same thing applies to the fore-part of my rudder when the ship is going ahead. Therefore if it is so effective in one case, it is only natural that it should be effective in the other. The only question is, to which is it best adapted, to the bow-rudder or the stern? We want to assist the old rudder, and we want to find out the best method of doing it.

Commander WARREN: I believe it is a most admirable thing for the stern, because I believe it is so good a thing for the bow.

Captain HENDERSON: That plan was tried on the "Great Eastern;" that is with a small piece before the stern-rudder, but it is not used now, it has been taken away.

Mr. RICHARDS: So far as I am concerned it is a new invention of my own.

Captain HENDERSON: You will find every native boat in Bengal has the rudder balanced; some have one-half the weight in front, and some have one-third.

Mr. RICHARDS: I am glad to hear that it has been used so extensively as you have described. It shows there must be some good in it.

Captain HENDERSON: If you will look in the naval model-room you will find the model of a Chinese pleasure-boat (see plate), which has that kind of balanced rudder.

Mr. RICHARDS: With regard to your own plan, if it be an effective kind of rudder, and it is used with success on small craft, why should it not be adapted to large ships?

Captain HENDERSON: I have spent a great deal of money in trying to introduce it, but I have been put down by prejudice among the sailors.

Mr. RANSFORD: I wish to know, Captain Warren, if you have ascertained the centre or pivot of a vessel on which she revolves?

Commander WARREN: That is such a vexed question, that if I begin I don't know where we shall end. Even with the stern-rudder alone it is a vexed question, on which point the vessels turn. I can give you my opinion, and it is this, that the vessel pivots on that point where the greatest resistance is met by the re-uniting of the water which is separated by the stem. That is to say, the fulness of the bow, we will say under the foremast, is the point under which she would pivot. I think Mr. Burton has demonstrated by a very beautiful instrument that the pressure or the action of the water on the stem is not so great as at the fulness of the bow where it re-unites. I think we can take that practically. The wave is split at the stem, and it re-unites at the fulness of the bow. With reference to the rudder described by Mr. Richards, I am told by a friend with a better memory than myself, that Lord Stanhope tried it in 1790. I thought it was about that date.

The CHAIRMAN: We return our thanks to Captain Warren for the very able exposition he has given of the principles of his bow-rudder. I am sure that there is no one here but will regard the trials that have been made with the "Sharpshooter" with a great deal of interest. I, for one, wish Captain Warren a hearty success; for, whether the Government adopt the plan or not, I have no doubt it will prove extremely serviceable to shipping generally.

Evening Meeting.

Monday, March 16th, 1863.

REAR-ADMIRAL SIR GEORGE BACK, D.C.L., in the Chair.

NAMES of MEMBERS who joined the Institution between the 3rd and 16th March, 1863.

LIFE.

Craig, J., Major Royal North Down Rifle Mil. 9*l.*
Balfour, F. W., Major late Rifle Brigade. 9*l.*

ANNUAL.

Clode, C., Esq., Solicitor to the War Office.
Wynne, G., Colonel R.E. 1*l.*
Cockburn, J. E., Lieut. R.A. 1*l.*
Carpenter, G. W. W., Major 32nd Light Infantry. 1*l.*
Nares, G. S., Commander R.N. 1*l.*

LIGHTHOUSES.

BY A. G. FINDLAY, ESQ., F.R.G.S.

IN the following remarks, it is proposed to treat of the important subject of lighthouses in a concise manner, as to their present condition. The subject necessarily embraces a very wide range of topics, to discuss all of which, would extend this paper far beyond its assigned limits; therefore, only the principal features will be adverted to. But it will be necessary, in order to make the subject intelligible to all, to advert to points quite familiar to those more initiated, and for which I must claim their indulgence; at the same time stating, that it is almost impossible to bring forward any matter new to those who have made it the business of their lives, and who have given the subject so much thought and study. Beyond the interest which a favourite subject has induced, I have no claims to advance of greater intimacy with lighthouse matters than any one else quite unconnected with them.

The literature of Pharology is very limited, and fifteen years since, scarcely existed. But since 1848, the fine works of Messrs. Stevenson and others have told us the main features of the systems, and are still almost the only English text-books on the general subject. The Parliamentary Report of 1861 has included most of the particulars of the system as in actual operation, but has added little to our previous knowledge, beyond some inferences at variance with previous decisions on the subject, which will be hereafter alluded to. I therefore propose to advert in the first place to the structure; secondly, the apparatus; thirdly, the illumination of lighthouses, appending to these, some observations on the comparative merits of the different points brought forward.

The Structure.—With very few exceptions the buildings erected in early times, for the purpose of directing ships at sea, were of the rude and simple nature of the ships themselves, and very frequently were of wood also. On land these buildings did not differ from ordinary structures, and need no remark. The difficulties encountered in the construction of a lighthouse on a tidal rock, covered and uncovered alternately by the sea, are of course mostly confined to the foundation and the works below the level of high water, and of the action of the waves. These difficulties have been of a most tremendous character, as the narratives of Smeaton and the Stevensons,—of their building the Eddystone, the Bell Rock, and the Skerryvore lighthouses,—most amply declare, but even these are not so exposed or difficult as some later structures which have been completed under the Trinity House.

Of the enormous force of the waves little must be said here. It has been measured at the Skerryvore, having struck an instrument placed for the purpose, with a force of 6,083 lbs. per square foot, and it is almost certain that this is not the maximum force which an exposed lighthouse has to withstand, and nothing but the utmost stability attainable by man, can be hoped to resist it. One often repeated fact must suffice here, as to what a wave can do. At the summit of the new Bishop Rock Lighthouse, off Scilly, a massive bell was fixed by strong iron supports, built into the masonry, at 120 feet above the sea. A wave ascended the tower (as is frequently the case to above the lantern) and had sufficient force to wrench off this bell and break the iron supports, very soon after its erection. All ordinary notions of requisite strength in a building must fall very far short of what is necessary in a building exposed to such forces as these.

Some of the earlier lighthouses on these exposed positions were of wood. Rudyerd's tower on the Eddystone, which lasted forty-seven years, between 1708 and 1755, is an excellent example of the ingenuity of our forefathers, and might have lasted till this time, had it not been destroyed by fire. This is cited, for we have just lost one of the most wonderful structures of the kind, which has been overtaken by modern progress, the Smalls lighthouse off the coast of Pembrokeshire. This most quaint and singular wooden barrack was built by Henry Whiteside, a violin maker, of Liverpool, for Mr. Phillips, a member of the Society of Friends. Whiteside commenced his

work, with some Cornish miners, in the summer of 1772, and from that period, till its demolition in 1862, it maintained its pre-eminently useful existence, amid all the storms and waves which assailed it. The narratives of its occupants and its builders, during the ninety years, of its career, would form a strange series; from the starvation and distress of Whiteside and his companions,—the death of one of the two keepers, whose companion, a cooper, headed him up in a cask, and lived a solitary man with his coffin for four months of stormy weather—to the man whose hair turned white from fright during a storm, which shook the building so as to empty a vessel standing on the table. Yet a most intelligent man, the head-keeper, with a wife and large farm on shore, is found to prefer this station, twenty miles from land, to any other, after eighteen years' residence. One circumstance, about this small freehold, is worth mentioning. When the Trinity House, in 1836, were compelled to purchase it from its private owners, 170,000*l.* were paid for it.

The first stone lighthouse, of its kind, was the Eddystone, commenced by Smeaton, in 1756. Its base only is uncovered at low water, and one of the chief difficulties in its building was to secure the lower courses from the sea, during the progress of the work. They were dovetailed and joggled together in an admirable manner, and each course secured to that beneath it by wooden trenails. As the holes in which these trenails were to fit could not be accurately done on shore, much valuable time was lost in making them on the rock, where minutes are treasures. The same occurred in the building of the Bell Rock Lighthouse, commenced in 1807, but in this case, the workmen lived on the spot in a wooden barrack, somewhat similar to the Smalls Lighthouse. In the much more massive Skerryvore (also built from a wooden barrack) some of these refinements were avoided, and reliance was placed more on the weight and massiveness of the structure, to give it the necessary stability, and the very broad base of the Bell Rock was abandoned for a figure much nearer the form of the Eddystone; thus saving a great amount of labour in the lower courses and foundation. Another advantage, it is thought, has been gained by a more perpendicular side, by its offering a less inviting figure to the waves for ascending the side of the tower.

In the noble towers which have been constructed of late years by the Trinity House, under the direction of the late Mr. James Walker, many of the difficulties and deficiencies of previous towers have been avoided, advantage having been taken of the experience then gained and also much ingenuity in simplifying the details.

The towers more specially noticeable are the Bishop Rock lighthouse, off Scilly, the advanced guard of our southern coasts; the new Smalls Lighthouse, which stood in glaring contrast, by its elegance, with the "strange, wooden-legged, Malay-looking barracoon" which preceded it, and that on the Hanois Rock, off Jersey. These have been erected under the superintendence of the Messrs. Douglass, whose services the Trinity House are most fortunate in securing, as this special branch of engineering requires the skill and energy that these gentlemen possess. They are at present engaged, I believe, in

the most arduous task of erecting a tower on the Wolf Rock, off the Land's End, which only uncovers four feet at the lowest spring tides, the exposed position of which may be judged of when it is said that with all diligence only eighty working hours were available on the rock in 1862.

The great distinction between these towers and their predecessors is that the stones of each course are dovetailed together laterally and vertically, so that the use of metal or wooden pins is needless. On the upper face, and at one end of each block, is a dovetailed projection, and on the under-face, and at the other end, is a dove-tailed indentation. The upper and under dovetails are made just to fall into each other, and when the hydraulic cement is placed on the surface, it so locks the dovetailing that the stones cannot be separated without breaking. Thus, when this cement is set and hardened, the whole of the base is literally one solid mass of granite.

Another advantage of this vertical dovetailing is, that it renders the joint impervious to the action of the waves, a very important point. In former cases this was effected by making a fillet on the outer edge of the lower course, into which the upper course was stepped.

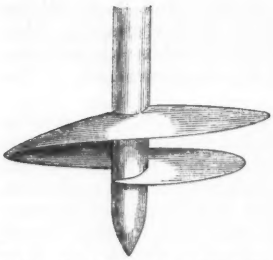
After the rock is prepared for the foundation—one of the most hazardous and difficult portions of the work—the stones are brought, most accurately prepared and fitted to each other on shore, and placed together in their destined positions with very great celerity. In some cases the works progress so rapidly, that two courses have been fixed in one tide.

The lower part of all these towers is a mass of solid masonry, and it is only made hollow at such a height as to secure it from the constant ravages of the sea. The upper part is arranged into several apartments, which need not be adverted to; and crowning all is the light-room, formed of very thick plate-glass set in frames, which are not perpendicular, but are placed diagonally, in order that they may not obstruct the light throughout the whole length.

These few remarks are all that is necessary on the structure, with the exception that it has been argued, and especially by Mr. Alexander Gordon, that there is no need of an extended base, the most costly part of the fabric, but that a simple frustrum of a cone would be preferable as offering a better face to the action of the waves.

The last observation leads to another class of towers, designed and erected by Mr. Gordon, consisting of iron plates bolted together. There are some very fine examples of his lighthouses at Jamaica, Bermuda, the Bahamas, and several other places. These are all excellently well adapted for positions and countries where skilled labour and materials are wanting. We have no experience of an iron tower on a tidal rock, but there is one consideration which would be entertained by the audience, now that the resistance of iron to blows is so much discussed—what would be the effect of a floating spar from a wreck urged end-on to it by the force of the waves?

Mr. Gordon's proposition of having all iron lighthouse towers of a uniform scale, so that the plates cast for one should fit the same position in all, is well worthy attention.



Extremity of Mr. Alex. Mitchell's Screw Pile.

One other form of lighthouse in use must be noticed—the screw-pile lighthouse of Mr. Alexander Mitchell. The Maplin, in the Thames mouth, was the first of these, began in 1838. It stands on nine piles, secured to as many iron screws driven to a depth of 22 feet into the sand. These screws consist of a single turn of a flange, 4 feet in diameter, on the lower end of the iron pile. These were fixed in nine consecutive days under the personal direction of its blind inventor, and by its stability has proved the usefulness of the structure. Other buildings have been constructed on the same principle at Fleetwood, Belfast, and other places.

The Maplin Lighthouse, erected by Mr. Walker, upon Mitchell's screw-pile foundation.

A few words may be said on light-vessels. England has more of these than any other country, except the United States; England has 47, the former 48, from the Nore lightship, the first in 1734, in one of the quietest positions, to the Seven Stones light-vessel, in 40 fathoms water, at sea off the Land's End. It is an expensive mode of showing a very imperfect light, but which has hitherto been unavoidable. They have been most useful aids to navigation, though their utility

may be in some degree impaired now that every ship is a floating light-vessel at night, with her mast-head and side-lights. Three men are required for a first-class lighthouse, but 11 men are required to man a lightship, the cost of which is 1,300*l.* per annum, while the lighthouse expense is about 350*l.* per annum.

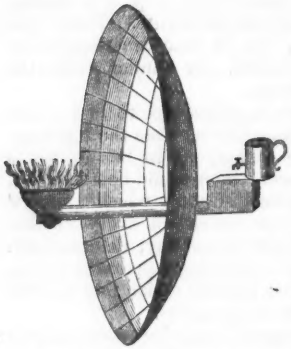
The Apparatus.—This subject is taken in precedence to that of the source of light, because it governs the latter rather than the converse. If light, or flame, could be produced so cheaply as to be not worth while to economise in an expensive manner, there would be no need of those beautiful adaptations of refined optical science, which are now in use. But as the question of making the utmost of every ray has been calculated and reiterated, till I would almost say, deferentially, that it has been overdone, as far as the controlling apparatus is concerned, it has reached a point of perfection beyond which there is little hope of improvement in the present form of apparatus.

It is not forty years since the original coal fire was entirely abolished in English lighthouses. They were wasteful and imperfect, but not entirely inefficient, for in some hazy weather the reflection of the fire, in the air, could be seen when the fire was invisible. The first controlling apparatus was a rude tin reflector placed over the fire, or a polished brass one behind it; but when oil lamps were introduced a more refined system of reflectors was established, on a perfect mathematical principle, which was soon brought into practical use, and still maintains its position.

Liverpool has the merit of having first adopted suitable apparatus for controlling the lamp-lights in its lighthouses, and this too on correct principles. William Hutchinson, a remarkable man, the dock-master there, first applied a paraboloidal reflector to his flat-wicked lamps, at some period between 1763 and 1767. An anecdote states, that prior to this a convivial company of scientific men met at Liverpool, and one of the company present wagered that he would read a book at the distance of 200 feet by the light of a farthing candle. This wager was won by means of a wooden bowl lined with putty, in which facets of looking glass were embedded and formed a reflector. Hutchinson was present, and seizing the idea, utilised it for his lighthouses. His reflectors were formed of tin plates or of wood lined with looking-glass, the largest 13 feet in diameter and 6 feet focus, placed behind a "spreading burner mouth-piece 14 inches broad." The Bidston, Hoylake, and Leasowe lighthouses were thus illuminated, and there is no doubt were most excellent lights for the period. It has been said that 1783 is the date of the first suggestion by M. Teulère in France, but England has this claim for the English system.

When the cylindrical wick'd lamp was invented about 1783, more perfect apparatus became necessary, and the present excellent reflector came into use, but was preceded by a similar though smaller arrangement—Wm. Hutchinson's, as in the example shown, which is one of the earliest reflectors used.

Before proceeding to describe this optical part, a few words as to its necessity, and the object to be gained, may be said.

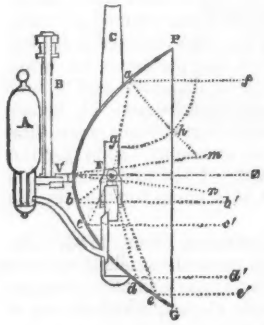


Mr. Hutchinson's Reflector, used at Liverpool, 1763.

It is required to show a light of the most brilliant character attainable in such directions only as it shall meet the eyes of the sailor afloat,—that is only over the sea near the horizon, all other rays that may pass in other directions are lost and useless; what is wanted is only a disc of light. Now, all well know that light passing from a central flame fills a sphere as "may be familiarly proved by observing that the light of a table-lamp falls on every part of the spherical ground-glass shade." All the rays which are thrown above a horizontal line which would divide this glass globe into two hemispheres would be lost, so that one-half the light would be wasted. A considerable portion of that falling below would also pass away uselessly on to the ground. The object of all lighthouse apparatus is to bend these errant rays, both above and below the horizontal line into the required direction of the sea-horizon.

This is done either by a polished metal reflector behind the light, or lenses before or around the light, or by a combination of both. The first is called the catoptric or reflector system, the second the dioptric or lenticular system, the third the cata-dioptric system, which, with other modifications, is called the holophotal system.

The *Catoptric* is essentially the English system, both from its having been originated and also from its having been justly retained here more than in other countries, for reasons hereafter alluded to. The reflector is of copper, lined with highly polished silver, formed to a parabolic curve, in the focus of which is placed the lamp, which has a cylindrical flame of about 1 inch in diameter.



Section of Parabolic Reflector and Lamp.

Its action is due to the peculiar properties of this parabolic curve. Briefly it is this, that a straight line drawn from the focus F of the parabolic curve P, V, G, to any part of the curve as F, *a*, will form, with the tangent to the curve at that point, an angle equal to that which a line parallel to the congugate axis V, Z, as *d*, F would make on the same point. And this property belongs to every part of the parabola. So that if the line F, *a*, were a ray of light from a flame at F, it would be

reflected in a horizontal direction from any portion of a reflector which was formed to such a section.

If the flame were a mathematical point of light, the reflector would send forth a cylinder of rays in a horizontal direction of the diameter of its opening, but as the lamp-wick has a diameter of nearly 1 inch it subtends an angle at the vertex V of a reflector of 4 inches focal distance F. V. of 14° 22′, the angle m V n. This is called the divergence of the reflector, and it spreads the light to this extent, and somewhat beyond it, for the refinements of mathematical calculation do not quite coincide with observed results. It would take 24 such reflectors to make a complete circle of light.

The Trinity House use for their lighthouses reflectors of 21 inches diameter, the sectional area of which is 346·3 square inches. For lightvessels the diameter of the reflector is 12 inches, with an area of 113 square inches, or less than one-third of the lighthouse instrument. The actual amount of the divergence of the reflected light is about 15°, but besides this there is the light of the unassisted flame which escapes outside the reflector, which has been economised in various ways as shown subsequently. As the flame has at least a surface of 1 square inch, and the parabola is adapted to a single point of light, there are many considerations as to the effect of different parts of the flame in being reflected, and very much has been argued on it, but the simple result of its acknowledged excellence is sufficient for the present. More will be said presently.

The form of reflector now in use is that calculated by Captain Huddart, an Elder Brother of the Trinity House, in 1791, and it has held its position admirably, amid all the optical changes that have passed. They are very lasting, as many of the reflectors now in use have remained unimpaired after thirty and forty years' continued service.

If there were no absorption or loss of light the effect of the 21-inch reflector, such as is exhibited, would be to increase the power of the flame about 346 times. About $\frac{12}{17}$ths of the whole light is thrown on to it.

Much has been said in its disparagement in comparing it with its more elegant and complicated rival, the lens; but again I deferentially urge that the great loss of light stated to be $\frac{44}{100}$ths of the incident rays, cannot be properly calculated, and these estimates must be founded on wrong premises, or the observed effects could not be accounted for. It is even said by some who are practically well acquainted with the subject, that a worn reflector, where the copper is exposed by the wear of the silver, shows nearly or quite as good a light as its more perfect neighbour.

The reflector for the floating light is only 12 inches in diameter, as in the example exhibited; larger sizes are difficult to keep horizontal, owing to the motion of the vessel, though they are carefully hung on gimbals. Its area is less than $\frac{1}{3}$ of that of the 21-inch reflector, but it has the best portion of the flame, and its divergence is much greater. It is a very great desideratum that a more powerful light should be obtained for the expensive and important position of a light ship.

For a *fixed* light, the reflectors are arranged around a circle or that part of it required to be illuminated, but not more than 14° or 15° of azimuth should be assigned to each instrument, a consideration not always fully carried out.

For a revolving light 18, 24, and even 30 of these reflectors are arranged on the faces of a revolving framework, which, by means of machinery, is made to show a face of 6, 8, or 10 reflectors in every direction at regulated intervals, producing a most brilliant light.

An intermittent light is produced by an eclipser being suddenly placed before each lamp which extinguishes the light suddenly, and by its removal, as suddenly unmasks it, giving a distinctive character from the revolving light, which gradually appears and decreases from its full brightness.

A great superiority has been claimed for the lens over the reflector, but in the enquiries made by the Royal Commission in 1858—61, although there was by no means a bias in its favour among the members, a singularly opposite result was arrived at, for out of 576 opinions of competent seamen, two reflector lights, Flamboro' revolving and the Lizard fixed lights, were preferred before all, as will be alluded to hereafter.

The present form of reflector was adopted by the Trinity House in 1788, three-quarters of a century ago, and has remained unchanged to the present day, but although it holds such a remarkably good position amid its lens competitors, I think it is by no means demonstrated that its utmost powers have been reached. A short time since I had the gratification of witnessing an experiment which convinced me of the contrary. It was made by Messrs. Wilkins, with the apparatus before the meeting, from the summit of the beacon-hill at Purfleet. The revolving frame of 4 sides carried a 12-inch reflector, a 21-inch reflector, such as is used in lighthouses, and a 36-inch reflector, the largest yet made, and which formed a prominent object in the nave of the Great Exhibition. On the fourth side was the polyzonal lens, illuminated with the 4-wick'd lamp. It was viewed from a position $3\frac{5}{8}$ miles distant. As a scale for the intensity of the lights there was, at one mile distant, several conspicuous gas lamps, and at various distances, from 100 yards to half a mile, were several other gas lamps. When the 12-inch reflector was turned on, it appeared quite as bright as the gas lamps one mile off; the 21-inch reflector showed a light more brilliant than those at half the distance, and when the 36-inch reflector was turned on (and on this point I wish particular attention), it was *brighter* than the nearest gas light.

It was unanimously considered by those present that the 36-inch reflector was as much superior to the 21-inch, as that was to the 12-inch reflector; that is, they were separated by about equal intervals. The openings of these reflectors contained an area of 113·0, 346·3 and 1017·87 square inches respectively, and they were each illuminated by an exactly similar lamp, the ordinary one-inch burner.

The great lens showed a light decidedly stronger than either, but of a different character—a whiter, more star-like appearance, precisely the difference between that of Venus or Jupiter, and of Sirius or

Arcturus. The lens light having a scintillating or radiating appearance, as a fixed star has. I know not whether this difference has been explained, though generally noticed.

The maximum divergence of the ordinary reflector is 14° 22′, this of 36 inches is only about $5\frac{1}{4}$°, consequently the whole light is concentrated into a narrow arc, but sufficient to give a flash of as much or greater duration as that of the lens.

Of course, the duration of the flash from the smaller reflectors was greater than those of the other two sides, but there was assuredly no advantage on this head with the lens over the large reflector. It certainly seemed that had there been *two* such reflectors that they would have outshone the lens, which, according to some calculations, should equal 8 or 10 ordinary reflectors.

The experiment left a very strong conviction that the large reflector was a most positive and marked advance over the others, and from this I think that it is most deserving of some consideration, whether, under some circumstances, this modification of the present excellent reflector might not be introduced with very great advantage.

The Dioptric System is essentially the French system, as it was in France that it was invented, and introduced by M. Augustin Fresnel, in 1823, in which year, a fine example of the apparatus was placed in the noblest existing lighthouse, the Tour de Cordouan, at the mouth of the Gironde.

From its complete success it was made the basis for the illumination of all lighthouses, which, under the law of 1825, were systematically constructed around the shores of France. From the inventor, it is sometimes called the Fresnel system, and, under his hands, it sprang almost at once into its present completeness, as far as regards the polyzonal lens and its accessories.

There has been some needless controversy about the origin of the annular or polyzonal lens. It began with those scientific toys of last century, the burning instruments. Buffon, the French naturalist, suggested in 1773, that it should be made in three concentric rings, or cut into steps, which was acted on by the Abbé Rochon in 1780; this lens, and one afterwards made by Messrs. Cookson, of Newcastle, were probably the only ones made by this most troublesome process. These inventions are alluded to in most of the works on burning instruments of the period. The next step was the proposition of Sir David Brewster, who, in 1812, for the same purpose, suggested that it should be built up of separate pieces. No mention is made at this time of its converse properties, that of distributing light. Lighthouses at that period had not attained sufficient importance to interest the world at large, and the excellent reflectors in use were considered to do their work perfectly.

The first proposal to use glass to control the light, is that recorded by Smeaton, in 1759, when a London optician proposed to grind the panes of the Eddystone lightroom into segments of a sphere. The statement is obscure, but the suggestion was not acted on. William Hutchinson, who first made reflectors at Liverpool in 1763 and 1765, is also an early claimant for the lens. He tried a hollow lens filled with brine,

but it broke with the heat of the lamp. The earliest *real* use of lenses was in one of the Portland lighthouses, where they were put up by Thomas Rogers, somewhere between 1786 and 1790. These lenses were 21 inches in diameter, and 5½ inches thick in the middle. Behind the flame of the lamp placed in their focus, and which was 3 inches in diameter, were placed his patent (spherical) silvered glass reflectors, 12 or 18 inches in diameter. These were covered without the use of quicksilver, and threw back the image of the flame, through the focus, on to the lens, thus shadowing forth the new holophotal system of the present day, as will be presently explained.

Similar lenses were placed by Rogers at the lighthouses at the Hill of Howth, Waterford, and also at the North Foreland, Kent, where they remained till the establishment was alienated from Greenwich Hospital, and came to the Trinity House in 1834. There were 15 of them, most carefully worked, 16 or 18 inches in diameter, and costing £50 each. They were also aided by the reflector behind the lamp.

These heavy lenses naturally absorbed much light, from their great thickness, but the intention was good, and their use demonstrates that much study had been given in these early times to lighting, when lighthouses were held rather as sources of profit than in estimation as useful sea-marks.

But all these adaptations of glass were inferior to the silvered reflector, and there is no question that their improvement and farther introduction into this country was impeded and retarded in later times by the difficulties that the excise duties and restrictions, placed on the large masses of glass required in their manufacture.

Augustin Fresnel invented the annular or polyzonal lens, or brought it into actual operation. The first occasion was in the autumn of 1821, during the progress of the Great Trigonometrical Survey of France, when one of 3 feet in diameter was shown across the channel from Cape Grisnez. Major Colby observed on this side, and he communicated the circumstance to Mr. Robert Stevenson, of Edinburgh, in November, 1821, and on July 23, 1823, a splendid apparatus was put up at Cordouan.

Prior to this there were but very few lighthouses, except in England; not more than seventeen or eighteen principal lights on the Atlantic coast of France, and from this date, as before stated, a complete system was adopted from the scheme drawn up by the French hydrographer, Admiral Rossel; and the new apparatus was alone to be used in all new lighthouses.

It is to this circumstance,—the French system being established at once,—that comparisons have been made in disparagement of our system, which, to a great extent, was in existence at the time, and had grown up with the requirements of an increasing commerce, or as means were obtained for the erection of lighthouses.

The dioptric system is dependent on the refractive properties of glass, which although generally well understood, I may be pardoned for briefly adverting to. When a ray of light passes obliquely from one transparent medium into another of different density, as from air into water or glass, it assumes a different direction at the common

surfaces of these two planes; a fact which is familiar to all in the appearance of a straight rod, an oar, or a mooring, when it dips beneath the water. At the surface it suddenly appears bent or broken (refracted) into a new direction beneath it. The same occurs with a ray of light through glass; and when it emerges from the other surface of the glass its direction is again changed. This change of direction, or the angle which the two directions make, varies with the density of the glass, &c., and that which it makes with a normal or perpendicular, is called the "index" of refraction. If the two surfaces of the glass are parallel, the issuing ray is in the same direction as the incident ray, the intermediate portion passing through the glass at a different angle.

If the two sides of the glass are *not* parallel the issuing ray will assume a direction relative to that surface and the air beyond it, and the light will pass in the three directions. The object of a lens is therefore so to arrange its two surfaces, that the ray it receives on one surface shall pass through the substance of the glass to the opposite surface, which latter is made at such an angle that the ray shall emerge in the direction required. This is a matter for rigid mathematical calculation dependent on the refractive index of the glass.

As a lighthouse lens is intended to deliver the rays which it receives from the focal lamp, at oblique angles, always in a horizontal direction, a plano-convex form is always chosen, both for the greater ease in working it, and for the purpose of more readily correcting, in these large figures, the aberration for sphericity. Other optical qualities are disregarded, such as the chromatic aberration, as the light to be dealt with is not a minute point, which would render greater attention necessary to these points, and as will be seen presently when the electric light is shown through one. As the flame is of considerable dimensions, its area neutralizes these difficulties.

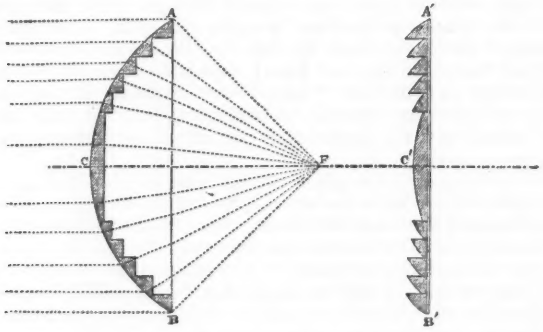
The plano-convex lens then is applied with the convex side away from the focal lamp, and the incident rays from that focus are refracted in the body of the lens, and finally pass out horizontally as required.

The converse of this is more familiar by the parallel rays of vision or of the sun, passing on to the convex side and centralizing in the focus, either magnifying it to the sight, or burning it by the sun's rays.

The annular or polyzonal lens acts in precisely a similar manner, and is formed on the following principle:—

The size of the lens being determined on, and its focal distance being also fixed, the normal form is assumed, as if it were to be a solid mass; but as the action of such a lens is due to the relative directions of its two faces, without reference to the thickness of the intervening glass, the convex surface of the lens may be supposed to be cut into concentric rings around a central disc C; A B C is a section of an ordinary plano-convex lens, whose focus is at F. As the great thickness of the central portion abstracts much of the light in its passage, the convex surface may be supposed to be cut into circular zones, whose section is as the shaded part of the diagram, and these

sections being all placed in one plane, as A′ B′ C′, the latter will have all the optical properties of the former, because the two surfaces are still of the same relative figure.



The annular lens can be built up to any convenient size, or made into the square figure of the example exhibited, for which I am indebted, as for the other apparátus, to Messrs. Wilkins and Son, who have done so much for lighthouse engineering.

The calculations for the curvature of these rings are necessarily abstruse; the methods of grinding and numerous other interesting features of their construction cannot be entered into here.

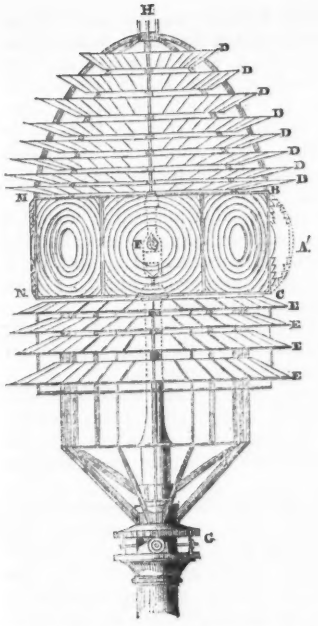
This lens is adapted for a first order apparatus, it is of 36·22 inches focal length; has an area of about 1,300 square inches; weighs about 1 hundred weight; and costs £60.

This lens is only adapted to a *revolving light*. Eight of them are built into an octangular prism, M, B, N, C, around the focal lamp F, and this is made to revolve by regulated machinery. The effect to a distant observer is a brilliant flash, of the size of the lens, each time that one passes before his line of vision. The brilliancy of this flash, according to some calculations, is equal to that of 3,000 unassisted Argand flames. By other estimates it is made somewhat lower.

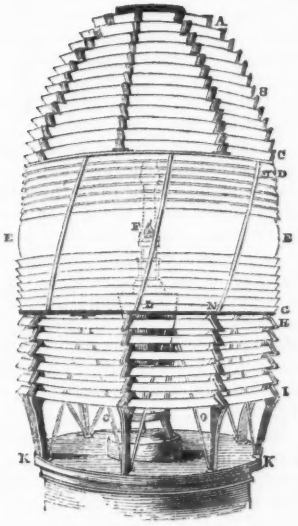
This portion of the apparatus only embraces an angle of about 46°, or rather more than one-fourth of the entire light. The rest is economised on a different principle, as will be presently shown.

For a *fixed* dioptric light, a different modification of the same principle is used. Instead of the central portion being made up of annular lenses, it is a cylindrical belt, of the section C, D, E, similar to that of the lens, made to revolve around the focus F in a perpendicular direction. The effect of this central belt E E is, not to distribute the light into eight beams, but equally all round the compass—that is, from whatever direction it is viewed a bright band of light, of the breadth of the flame F from the lamp L, is visible from top to the bottom of the central belt.

In the first instance this apparatus was made a polygon of 32 sides,



View of a first order *revolving* Dioptric Light, with upper and lower *reflecting* Zones.



View of a first order *fixed* Dioptric Light, with upper and lower *refracting* Zones.

but in 1836 Messrs. Cookson made one entire, which was the greatest step then achieved.

In the separate panels of which the central belt is made up, the sides are not perpendicular, but diagonal, M, N; forming them into rhomboids, in order that the metal framework which holds them together, should not obstruct the band of light throughout their whole length, in any one direction.

For the remainder of the light, which passes over and under the central zone, different means have been applied to economise it. In the first apparatus, the revolving light of Cordouan, and in similar apparatus at the Skerryvore, a complicated arrangement of eight smaller lenses are placed over the principal lenses, in a conical form. These throw the light diagonally upward, and it is then received on to eight long plane mirrors, diverging outwards and upwards from the centre of the apparatus, and which reflect the bright images of these eight smaller lenses into a horizontal direction, adding their power to that of the central lenses. This form of apparatus, though beautiful and effective, is not now much used.

Another form of upper and lower zones was also at first used, but in new apparatus is abandoned. It consists of a series of rings diminishing in size above the apparatus; to which were attached a large number of plane mirrors, formed of looking glass, which *reflected* the image of the flame thrown on to them in a horizontal direction. The same system was applied below the central zone. (See D, D, E, E, in diagram on p. 231.) Strictly speaking, these ought to have each formed a portion of a parabolic curve, suited to the focal lamp, but the size of the flame rendered this refinement of less consequence.

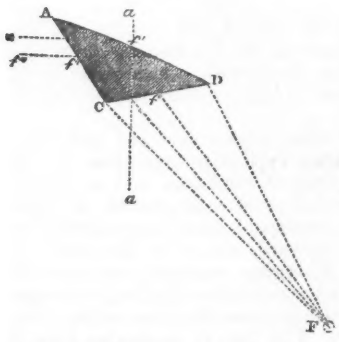
In the outset of the dioptric system, the smaller apparatus, and at a later period in the largest apparatus, a much more beautiful and effective plan was introduced for these supplementary zones. The first, on a large scale, were the lower zones of the Skerryvore light, by Alan Stevenson, since which they have become universal.

These are totally-reflecting-cata-dioptric prismatic zones—a long array of words, which however are expressive; the particular action of which may be explained by a very familiar experiment.

Place a stick of sealing wax, a pencil, or any other substance, in a sloping direction from you in a tumbler of water. Raise the tumbler above the level of the eye, until, at a *certain angle*, you will see the image of the sealing-wax, &c., *totally reflected* under the *upper* surface of the water.

Importing the principle thus demonstrated into the lighthouse service, these zones act as may be thus explained. In the diagram representing a section of a zone, A, D, C, which is so placed in regard to the focus F that a ray falling from it at *f* will be so refracted on to the side D A at *f'*, that, instead of passing out, it will be *totally reflected* (as in the tumbler of water) at that point of incidence *f''*, into the direction *f'''*, and finally pass out in the required direction. This angle *f f' f''* is less than 41° 49′, as with more than this it would not be reflected, but pass out upwards.

This beautiful optical arrangement is well exemplified in the apparatus before the meeting.



In a first order light there are eighteen of these zones above the central belt, and eight below it; the entire apparatus forming a most beautiful object 10 feet high and 6 feet in diameter, a view of which has been previously given, costing, for the optical portion only, about 1,300*l*. The public were familiarised for the first time with it at the Exhibition of 1851, and the much more beautiful series shown in the nave of that of 1862, especially that by the Messrs. Chance, gained universal admiration.

The dioptric apparatus is divided by the French into six orders or

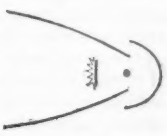
sizes; from the powerful first order 10 feet in height to the small harbour lens of 11¾ inches in diameter.

Thus far have we explained the apparatus for the revolving light, with its eight lenses, and that for the fixed light; but there is another appearance not used in the English lights, but which is largely applied in France and elsewhere. It is termed the "Feu fixe varié par des êclats." A fixed light, varied by flashes, preceded and followed by short eclipses. This appearance is obtained in various manners under the original dioptric arrangement; one of the most usual of which was to make two or three panels of vertical lenses revolve around the fixed horizontal apparatus; thus collecting all the beams which fell on them into one ray of the breadth of its face. It is now managed in a different manner. The apparatus is formed of alternate panels of fixed and revolving elements, or of central zones and annular lenses, which, when the entire apparatus is made to revolve, will produce the appearance in question. These brighter flashes generally appear at long intervals of 3 or 4 minutes; and it has been objected that under difficulties of bad weather, or want of close watching, that the flash might not be seen, and the light mistaken for an ordinary fixed light, which it otherwise resembles. Sometimes this flash is coloured red, and, but rarely, green.

Up to a recent period the lens manufacture was exclusively held by the French (with the exception of Messrs. Cookson) from the superiority of their glass; and this advantage, maintained by our fiscal regulations, led to the construction of a large portion of our light-house apparatus, by MM. Soleil, François, Letourneau, Sautter, &c., in Paris. Later, however, our country has had the advantage of the enterprize of the Messrs. Chance, of Birmingham, who, aided by the scientific attainments of Mr. James Chance, have placed some of the finest examples in the world in our recent lighthouses, and also have reached a perfection leaving little to be hoped for.

Hitherto, the remarks have applied to the apparatus as originally employed, in which there is still some loss of light in certain directions, both in the lens and reflector. This consideration has led Mr. Thomas Stevenson, one of that family to whom practical pharology is so much indebted, to propose some arrangements which he has termed the holophotal system, from two Greek words signifying "whole light."

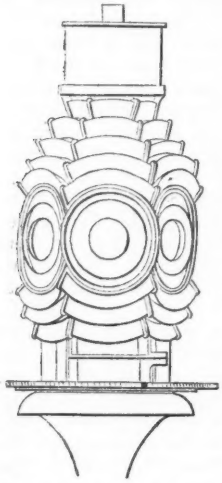
The ordinary reflector is made holophotal by cutting off the part behind the focus, and substituting a hemispherical reflector behind the flame, in front of which, and in that area which is not controlled by the parabola, a small lens, the action of which combination will be understood by the diagram.



In the apparatus before the meeting, a "direction-light," also kindly furnished by Messrs. Wilkins, and which stood in the nave of the International Exhibition, is an example of the first application by Mr. Thomas Stevenson of his system. He proposed it in 1849, and the Horsburgh lighthouse, in the Strait of Singapore, has nine such

reflectors for its revolving light. The diagram will show that *all* the light is economised. It consists of a spherical reflector behind the light, which throws all the posterior rays on to the combination of annular lens and prisms in front of it.

Some approach to this arrangement was made by Mr. Gordon, in 1847, and also by Thomas Rogers, in 1793, as before stated.



Holophotal *revolving* Lens.

In revolving lights all the rays are thrown into the beam of the great central lens, by making the upper and lower reflecting prisms of a corresponding curve, as in the apparatus exhibited, thus increasing the power of the flash, but making the intervals nearly dark, as the whole surface of each lens is luminous when presented during its revolution, and no light passes at the angles.

This subject might be pursued to a very great length with the variety of plans suggested and in operation, but time will not allow of it.

The Flame.—All are familiar with the cylindrical wick'd lamp; by means of which both sides of the flame are exposed to the current of air necessary for combustion. This was not invented (by Argand, a citizen of Geneva), till 1780 or 1785, and then it was almost accidental He had been vainly trying to make the air ascend through his tubular wick, when his brother unintentionally placed a broken bottle neck over the flame, when it shot up into a brilliancy that sent Argand into raptures, and by its immediate introduction in general use, must have had a most important bearing upon the social condition of the world at large. For it is difficult to conceive how our ancestors, before this, pursued their avocations by the light of the miserable torch-like lamps, or the smoking candles then only attainable. Argand's lamp was perfected at once, and now is exactly as he left it. It is used in all reflector-lights, with a wick $\frac{7}{8}$ths inch in diameter.

For the great dioptric lights a different modification is used. It is a complicated mechanical lamp (when of the best form) with four concentric wicks; the outer one 3·39 inches in diameter, the inner one $\frac{8}{10}$ths of an inch. The great heat from this lamp would char the wick, if means were not employed to keep it abundantly supplied with oil, which is effected by four small pumps, kept in action by clock-work, which causes the oil to flow over the wicks much faster than it is consumed; after which it is filtered and returned to the reservoir. For the smaller apparatus, lamps with three or two concentric wicks are used.

The quantity of oil consumed in the 1-inch burner *ought to be* about 48 or 50 gallons per annum, and in the great Fresnel lamp of four

wicks, about 750 gallons per annum; for it must be remembered, that the quantity of oil properly burnt, is an exact index to the amount of light produced. It is most essential that the flames should be kept of a proper height, or much power is lost, and the upper part of the flame is, in each case, that which falls upon the sea.

Gas, with but few exceptions, is not used for lighthouses, though a most desirable light, both from its brightness and the power of producing a flame of any dimensions, but from its nature, it is inapplicable to situations where it cannot be properly produced.

Colza oil is now the fuel used in our lighthouses. It has been so since 1846, prior to which the best sperm oil was alone used. The change is fortunate, for the industry of the American Whalers has nearly destroyed the source of that oil. Colza oil is made from the seed of the colza or colzat, a species of wild cabbage now extensively cultivated for the purpose in Normandy, &c., and is a very excellent, a superior substitute, for its expensive predecessor.

A brighter flame than that now used, but of equal dimensions, is a very great desideratum, but it has not yet been satisfactorily obtained. Whether any modification of the lamps burning the new petroleum, or other mineral oils, could be brought to bear, I know not—the direction is worth trying.

An improved flame would have a most important bearing on the system, for a small per centage of increased brightness, would more than outweigh all the contrivances which have been made to economise it, and it would be multiplied to a large extent by the optical arrangements; and now that lighthouses are in competition, as it were, with passing ships, each with its lights, frequently excellent, it has become a still greater want.

One proposition by Mr. Gurney, in 1835, of impinging oxygen gas on the flame had the desired effect of vastly increasing its intensity, but could not be carried into practical use, and we are met at once with the difficulty of procuring and storing the gas.

The same obstacle also intervenes with another splendid light, that first proposed by Lieutenant Drummond, 35 years since, and which was then largely experimented on—the lime light. It could not be made to act with certainty and steadiness, an imperative necessity with lighthouse purposes. A modification by Mr. Renton obviates some of the difficulties by enclosing the lime cylinder in a wire cage, which prevents its cracking and breaking off, but I believe there are great difficulties in placing it in a lighthouse, one of which is, the want of oxygen gas.

We come now to another light, which in one instance only has become a part of our lighthouse system—the magneto-electric light—now permanently established at Dungeness. This is the first real step in the very important point of increased illumination, and in the almost equally important particular, of a different character of light.

This light which was in operation in the Great Exhibition of 1862, was certainly the greatest wonder that that world of marvels con-

tained, and a feeling of awe arose at the contemplation of a machine, that of itself, gathered together, from separate masses of quiescent iron, that mysterious agency, or power, or force inexplicable, by which nature's processes are carried on, and by which our very life and actions are maintained, and made it manifest to the sense in light as glorious as the sun itself. The whole process is a marvellous illustration of that correlation of each physical force in nature's workings—an evidence that one power may be traced throughout a train of operations until it emanates in a totally different form, and yet that all these phases of action are identical.

It is to the talents and assiduity of Professor T. H. Holmes, that this extraordinary machine is owing. I am sure that it must have cost years of labour and thought to solve the problem of a continuous and equable current of electricity, or magnetism, for by their action in this they are shown to be identical. All previous attempts were made by the action of the galvanic battery, which, as is well known, cannot well be maintained at a constant state of power.

Briefly, the action of the magneto-electric machine is this. A triple series of permanent soft iron magnets, arranged in a circle, are made to give off their influence to a series of electro-magnets attached to a revolving wheel, from which it passes to the lamp as a single current, and then through the minute space between two carbon-pencils, where it shows, not a flame nor incandescence, but a light of the most intense brilliancy, not more than $\frac{1}{6}$ or $\frac{1}{8}$ of an inch in cubical dimensions.*

It was in successful operation in one of the South Foreland light-houses for nine months of the year 1859, and since June of last year has been in constant use in the Dungeness lighthouse, and is, therefore, essentially a part of our lighthouse system.

It is difficult to estimate the intensity of this light, but I have heard that, viewed from the Varne lightvessel, midway between it and the Grisnez revolving light (one of the best of the French lights), the *fixed* electric light equals, or exceeds, the brightest flash of the Grisnez light, which is eight times as strong as the fixed light would be. Again, an experiment was made with it, and the reflectors still remaining at Dungeness. They were shown alone, and were distinctly visible from the distant station. The electric light was then shown in addition, by which, of course, the strength of the lights was immensely increased. The oil-lamps were then extinguished, and not the slightest decrease of power was observed; so that all the previous light made no perceptible addition to its power.

One most important feature is the entirely distinct character of the light, it cannot be mistaken for any other light; and this fact gives a great power of multiplying our lights without causing confusion. And it may now be applied most usefully by superseding some of the

* Mr. Holmes subsequently explained the operation of his lamp, which was acted on by the galvanic battery instead of the appropriate magneto-electric machine above-mentioned.—A. G. F.

existing lights where there are greater necessities for having a well-marked starting-point.

It may be urged that it would be difficult to place it in many of the isolated stations, such as the Bishop Rock, or the Eddystone, from the difficulty of finding a place for the necessary steam-engine to drive it. I would venture to suggest that there is a power at hand, ready to be impressed in this service, in the ceaseless action of the waves and tide. A series of levers acted on by this force, might be made either to pump water to an upper story, or to raise weights, which, by their descent, would give the necessary motive power.

For a floating light, which most of all requires improved illumination, there is the constant tug at her moorings, which might be applied to a series of springs or accumulators, by which their power might be husbanded for the same purpose.

Reverting to the question of lightvessels, to which, if the electric light can be applied, will give them a vastly increased importance, it may be said that the dioptric apparatus is not applicable. Their constant and irregular motion defies all efforts to produce that stability necessary to the action of such optical apparatus, and although the Trinity lightships have been universally praised, as far as they go, still an advance, as I think with others, can be made.

Mr. Herbert's proposed form of floating-vessel has been found to act exceedingly well in many places, and at Liverpool it is, I believe, exclusively used in that important port for the large floating beacons. They are circular and are moored from their centre of gravity, or near the surface of the water as shown in the section; and the effect of the form and mooring is such that no other floating body possesses such stability. In evidence of this, a bell-beacon on this principle was moored off the entrance of the Queen's Channel, and its motion was so slight that it would not ring the bell at the top of the shaft that rose from it. Such a floating vessel would be excellently adapted for the electric light, as it could accumulate the necessary power either from its mooring, or from the passing of the tide.

Mr. Herbert's proposition to use these floating lights was a grand one. It was to moor a line of them along the fairway of the English and St. George's Channels, in the former at each degree of longitude; so that by their means vessels might avoid the dangerous proximity of the coasts, and yet be perfectly assured of their situation, which is the only object often gained by closing with the land. This scheme is of daily increasing importance from the increase of steam-vessels, and of that gigantic evil, collisions at sea. The proposal is, that all vessels going down channel should keep to the north of this line of lightvessels, and those coming up to the southward of it, thus almost annihilating the chances of falling foul of each other, and which, with the use of steam, would render it a matter of no difficulty. There are numerous other features connected with it which I regret that time will not allow me to dilate on here. Respecting its practicability, till it is pronounced not to be so by ample experiment, we may feel assured that the engineering skill which has surmounted much greater apparent difficulties than this, could readily accomplish what many deem a most important result.

FIG. 1.

FIG. 2.

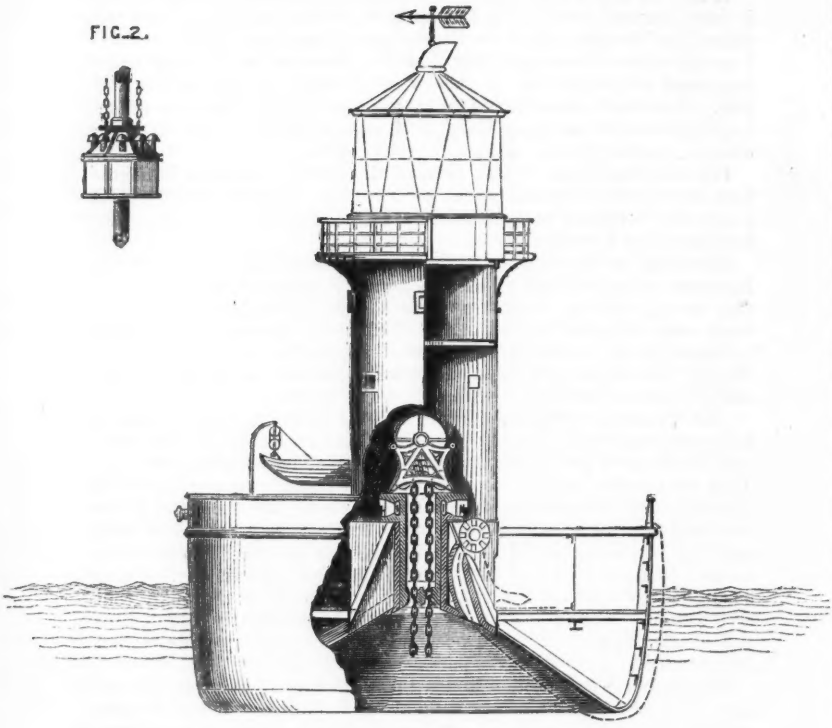


Fig. 1.—Mr. Geo. Herbert's proposed Floating Light.
Fig. 2.—Ordinary Lightvessel Lantern on the same scale.

General Remarks.—There are some points in the economy of lighthouses which have been, and perhaps are still, the subjects of controversy, of misunderstanding, and even of misrepresentation. As was said before, there are few works extant on the subject, and these have been drawn up from a point of view which has somewhat of a tendency to elevate the dioptric principle in its comparison with the reflector, and in this, some positions have been advanced which I respectfully deem to be fallacious. It has been said that a large proportion of the light—even one-half and more—is lost by absorption in a metal reflector, and that for this, and other reasons, the lens is from $2\frac{1}{2}$ to 4 times as advantageous as the reflector. Upon this

assumption it has been asserted that our Trinity House, as the guardian of our coast-lights, have failed in their duty in retaining the reflector, when a better system was introduced.

Going much farther than this, it has been broadly stated that our country will bear no comparison with others as regards the lighting and buoying of its coasts. These opinions, held in high quarters, led to the appointment of a Royal Commission in December, 1858, which, in the $2\frac{1}{4}$ years it occupied, made a most rigid investigation of the subject (omitting, however, some very important points). The voluminous Report of this commission, if it has added little to our previous knowledge, has at least brought forward many testimonies at variance with the assertion and spirit which led to its appointment.

I said, in 1847, when but little was generally known of lighthouses, and less had been written, that if our English lights were so inferior to the French (the former being reflector, the latter lens lights), every sailor in beating up the English Channel was able to judge for himself, as he came in sight of each coast alternately, and would most assuredly have availed himself of the Englishmen's privilege, to grumble at what he was told he was paying very dearly for, if our lights had any inferiority. But no such complaints were ever recorded. From 1858–60, the opinions of 576 mariners were collected by the Royal Commission, and as it is for this class alone that the lights burn, their evidence outweighs all other. To the question "what British light have you seen farthest off?" the following are the number of replies in favour of each. *Reflector*, revolving, 260; intermittent, 29; fixed, 90. *Dioptric*, revolving, 85; flashing, 56; fixed, 9. So that 260 mariners have named 10 first-order *reflector* lights (there are only 13), while out of 10 lens lights, only *two* are named.

This, I think, most conclusively settles the question as to the propriety of retaining the reflector. It is a very remarkable circumstance, that the two most generally named, are the Flamborough revolving, and the Lizard fixed light, the latter of which theoretically would be far inferior to its rival, the lenticular fixed light.

Carrying the comparison a little further—that is, between the British lights and those of the rest of the world—by referring to the Report, we find that:—

Of 715 mariners only 17 think our coasts *not* well lighted; of 586 mariners 8 think our coasts not so well lighted as some other countries, while not one foreign witness prefers the lighting of any foreign shore.

This is as to the *quality* of the British lights. Now for a few remarks as to their quantity. In the Report—France, being taken as a standard, has one light for every 12·3 miles of her coast.

England (whose 41 very important floating lights are excluded) has one for every 14 miles; but if the lightvessels are added (as they ought to be), it excels France, for the unit is 11·37 miles.

Ireland is said to have only one light to 34·5 miles, and this curious result is arrived at by measuring the distance between them around the sinuosities of the intricate coast which separates them.

Scotland, by the same geographical process, has only 1 light to 39·5

miles of coast, or, as it is said in the Report, "France is more than three times" as well illuminated as Scotland or Ireland

Now, I would appeal to the chart of the lighthouses of the most important commercial part of Europe, as recently prepared for the Trinity House, which I have the honour of laying before the meeting, to demonstrate that these figures, and the inferences they might induce, are absolutely erroneous.

The western and very intricate coasts of Scotland, which are made to swell the mileage, and reduce the average of its lighthouses, has neither ports, shipping, commerce, nor products; and, what is of more consequence to the present question, it has no shipwrecks. Had these coasts been measured on the same system as the straight French coasts have been, Scotland or Ireland would be shown to be as well guarded by night as any other country.

The lenticular system, in its various forms and arrangements, may be pronounced to be nearly perfect. The next source of improvement may be taken for the flame itself, which now outweighs all other points, and is deserving of much consideration. The character of the light, as in the electric or lime light, I strongly urge is of the greatest importance. With respect to the reflector, I have pointed out what I think is a direction for further trial. Many other points might be here brought forward if time permitted, but what has been said must suffice. The system is deserving of much consideration for the many beautiful adaptations of refined science which are in use.

The Trinity Corporation, the guardian and chief director of the lighthouse system, I have been explaining is one of the very few, if it be not the only one, that has come down to us from the middle ages (for it dates from temp. Henry VII.), occupied the most honourable and useful field it has so well filled, and for which it was instituted. Those who have any veneration for the past history of our country in its better phases, must desire to have that transmitted to posterity, which in the past and in our own times has proved of such immense benefit to the world at large.

I have thus most briefly alluded to the main features of the subject, leaving many others of great importance untouched for want of time and consideration for your patience. But I cannot conclude without thanking the Messrs. Wilkins and those gentlemen who have enabled me to illustrate what I have said, with the beautiful and costly apparatus before you.

Mr. FINDLAY: In reply to a question as to the achromatising the lenses, I should say that I only just alluded to it, as in practice the correction for the chromatic aberration is disregarded. The annular lens exhibited is adapted for a flame of 3 or 4 inches cube, which neutralises all the effect. But when a minute point of light, such as the electric light, which is not $\frac{1}{4}$ of an inch in diameter, is placed in its focus, this aberration becomes very manifest in the beautiful coloured rings it displays. Such a light requires a special lens.

The electric-lamp exhibited is that of Professor Holmes, and is the same instrument as was shown from the summit of the Monument at the recent illuminations. But it is not lighted now by the means to which it is adapted. It is now in action by means of a powerful galvanic battery of the ordinary form. Its proper apparatus is the magneto-electric machine, such as that shown in the Great Exhibition, which perhaps Professor Holmes will presently explain.

The CHAIRMAN: Professor Holmes will perhaps explain his electric lamp.

Professor HOLMES: To produce a constant electric light, it is requisite that the carbon points should be maintained separated to a distance proportional to the strength of the current; but, in order to light the lamp, the points must be brought in contact for an instant, because the current of electricity produced by a galvanic battery, or a magneto-electric machine, will not pass through space—in other words, has no "striking distance," as it is termed. On separating the carbons, however, the current continues to pass—which, at the first blush, seems to contradict the statement I have this moment made, that it will not pass through space; but this is explained by the fact, that the intense heat generated by the electric current liquefies a portion of the carbon, and that the current passes from one carbon point to another, not through empty space, but through the carbon thus liquefied. This lamp before you is now placed in connection with the galvanic battery, but, as you perceive, there is no light. I now bring the points in contact, and I beg you to observe that the moment they touch, the light is produced in its full intensity; but if the carbon points remained in contact, no light would be produced; the current would then pass from the point of the upper to that of the lower carbon, as it does through the bodies of the carbons themselves, without giving any light; therefore, you may conclude that the lamp has, by some contrivance in its construction, separated the carbons the instant they touched. This contrivance exists, and I shall explain it presently; but I may here remark that this function of the lamp is of paramount importance, for, without it, should the light be extinguished, by diverting the current for an instant, the points would run together, and remain in contact, when, as I observed before, no light would be produced, until the lightkeeper in the lighthouse himself separated the points by hand. Having put this part of the lamp out of action, and allowed the points to run together, you perceive there is no light until I separate them by hand. I now however allow that part of the lamp to act freely, and again extinguish it in the same manner as before, that is by diverting the current. You perceive that so quickly does the light re-appear that I deem it necessary to repeat the operation in order that you may be quite assured that it was really put out. Having thus shown you the peculiar action of this lamp, I will proceed to explain its construction, and the principles therein involved. Two cords are wound in opposite directions upon a compound spindle of different diameters; these cords, by means of pullies, when the spindle is turning in one direction, will be wound on the small diameter, causing the lower carbon-holder to rise, and will be unwound on the larger diameter of the spindle, causing the upper carbon-holder to descend with double the velocity that the lower carbon ascends. That being the ratio of the combustion of the two carbons, the luminous point is maintained constantly in the focal plane. But it is nearly impossible to obtain carbons of equal hardness; hence, though the ratio in the movement of the lamp is adjusted to the ordinary ratio of combustion, still cases may occur where the upper carbon, say, may be harder or softer than usual. In the first case, the luminous point would descend below the focal plane; in the second, would ascend above it. This is the only circumstance that renders necessary the attention of the lightkeeper during the combustion of a pair of carbons. A short time after lighting up one pair of carbons, the keeper observes whether the luminous point maintains its position: this he does, not by looking at the light, which, in such close proximity, would be injurious to his eyesight, but by noticing the position of the rays on the frame of the lantern, where two black lines are marked so as to enable him to judge instantly whether the luminous point is ascending or descending. Whichever it may be, the light is brought back to the focal plane by simply turning this button to the right or to the left—to the right, lowering the points, to the left elevating them. The manner in which this is done may be thus explained. What may be termed the fixed end of the cord connected with the lower carbon, is wound on a small spindle terminating in this button; by turning it to the right, this cord is unwound, and the lower carbon descends, and is followed by the other carbon; by turning it to the left the cord is wound on this spindle and the lower carbon is elevated, but as this will not elevate the upper carbon this is generally done slowly, so as to follow the upper carbon as it burns away. An expert hand will turn the two at once, and do it in an instant. This, as I have ob-

served, is the only point to which the attention of the lightkeeper is necessary; but, after two or three months' practice, a lightkeeper will pick out for use pairs of carbons of equal hardness, which will maintain their exact position in the focal plane, and need no manipulation. I now bring my remarks back to the movement of the carbons. You will observe that, by winding up the lamp, I separate the carbons several inches, and in removing my hand, the carbons, as you perceive, run together with considerable velocity. (No spring is employed for this movement,—the weight of this tube which carries the upper carbon, in unwinding its cord causes the spindle to revolve and wind the cord of the lower carbon on the smaller diameter). This rapid approximation would continue until the carbon points touched, and unless obviated by mechanical contrivance, the carbon points would always be in contact, and no light could be produced. To prevent this, and maintain the carbons at their proper distance, an electro-magnet is employed with a lever, balanced on a fine steel fulcrum and placed over the end of the electro-magnet, carrying an adjustable piece of soft iron opposite the end of the electro-magnet. This lever is about six inches in length, and the fulcrum is an inch and a half from one end. To the short end of the lever is attached a spiral spring, capable of being strengthened or weakened by turning this button right or left; the other end of the lever carries a catch, pointing downwards, similar to the tooth of a wheel. On the end of the spindle, on which the cords are wound, is a toothed wheel about six inches in diameter which revolves with the spindle; this wheel takes in to a pinion fixed on another small spindle, on which spindle, immediately under the lever, is fixed a small wheel composed of a boss, into which are inserted twelve pieces of steel wire about two inches long, each placed like capstan bars; the outer points of these wires being all bevilled off on one side. The use of the lever is as follows:—The electricity, before passing to the upper carbon, has to pass through the wire wound on the electro-magnet already mentioned. The strength of this magnet is proportional to the quantity of electricity passing through the wire, and the quantity of electricity passing is again proportional to the distance between the carbon points,—therefore, the strength or attractive power of the electro-magnet is proportional to the distance between the carbon points. Now, to regulate the lamp for a given current, and a given distance between the points, all that is necessary is, in the first place, to adjust the piece of soft iron carried by the lever to such a distance from the end of the electro-magnet that the force exerted on it to draw it down should be somewhat proportioned to the strength of the spring attached to the short end of the lever. This is what I term adjusting the lamp for a given current; and when once done, requires no further adjustment for small variations in the current. Now, I must ask you again to follow me through the motion of the lamp to realise its working with more perfect exactitude. The descent of the upper carbon causes the main spindle to revolve; the large wheel fixed to this causes the second spindle to revolve through the pinion into which it is geared; thus the star or capstan-wheel is caused to revolve with twenty-four times the velocity that the main spindle revolves; but when the current is passing, the electro-magnet attracts the iron fixed in the lever, thereby drawing down the lever to a distance regulated by set screws, such that the tooth or catch at the long end of the lever catches one of the bars or wires of the star-wheel, and thus prevents all motion in the lamp. The stud or button that acts on the spiral spring at the short end of the lever is turned so as to strengthen the spring sufficiently, that when the carbons are at their proper distance asunder, the strength of the spring which tends to lift the lever, and the strength of the current round the electro-magnet, shall exactly balance one another. Then, as you can readily imagine, the slightest increase of distance between the carbons will give the preponderance to the force of the spring, the lever is lifted by it, and the carbons approach; but the moment the carbons approach by the smallest distance nearer to one another than the balancing distance to which the lamp was regulated, the electro-magnet is more powerful than the spring, draws down the lever, and stops the approach of the carbons. This action is being continually repeated during the whole period of the combustion of the carbons,—each approachment of the carbons being but the four-hundredth of an inch, a variation so small that the distance between the carbon points may be said to be uniform: and as every variation in the distance between the carbon points causes

a difference in the amount and colour of the light, this uniformity of distance attained in the present lamp is the cause of the steady and uniform light which it produces, and which you now observe. I must now pass to the second part of the mechanism of this lamp—that is, the part which causes the instantaneous separation of the carbon points on their coming in contact. A second electro-magnet is employed for this purpose, placed under one end of a lever whose fulcrum is in the centre; to this end is suspended a small piece of soft iron, within about an eighth of an inch over the end of the electro-magnet; to the other end of this lever is fastened the fixed end of the cord passing through the pullies of the upper carbon-holder. Now, when the current is not passing, the piece of soft iron is, as I have just remarked, about an eighth of an inch from the end of the electro-magnet. The moment the carbon points touch, the current causes the piece of soft iron to be instantly attracted, drawing down that end of the lever, elevating the other, and with it the tube carrying the upper carbon to the extent of half that distance, or one-sixteenth of an inch, owing to the double pullies. There is a bolt here, which, if I push in, stops the action of this lever; and here also is another one which, on being pushed in, stops the movement of the clock-work. You see I put the light out simply by pushing in this first bolt, and diverting the current for an instant. If I had not shut that it would light again. The operator can maintain the points of the carbon at any distance he requires. But you have heard of arcs of light, four inches, three inches, two inches, in length; why do I burn it the one-sixteenth of an inch? Every piece of apparatus in a lighthouse has a focus, or ought to have. If I have two luminous points (and two ends of carbon would be two luminous points), and if they were one inch asunder, I should have them half an inch out of focus. Again, the further they are apart, the more coloured is the light. The object is to have light as much like sunlight as possible. In ascending the stairs of Dungeness lighthouse,—where the Magneto-electric Light is in operation,—it is a most extraordinary thing to observe the light; it always appears as if it was the dawn of day; it never looks like gaslight.

Another thing in this lamp is its absolute steadiness, although every current requires a little regulating. At present this is over-regulated, and I must just alter it a little, and then it will go on smoothly. It is not intended for a galvanic battery (as used in this); but the idea has always existed in most people's minds that an electric light is a thing that is unmanageable. In this with the magneto-electric machine it is perfectly manageable: there is no difficulty whatever. All that the lightkeeper has to do is to mind this one regulator; if it hisses like that, all he does is to slacken this a little. If the light be too close, it hisses; if too far off, it jumps. In that way he knows by the sound whether this is over-wound or under-wound. An ordinary lightkeeper, with no more capacity than a bricklayer's labourer, can manage this.

The CHAIRMAN: Is this the lamp which has been in continual use for two years?

Professor HOLMES: Not all, but some of the time. At first my difficulty was the obtaining a lamp. I had Duboscq's, and then I tried Serin's. I tried different electric lamps, but they had always this fault, that a man never could leave them for fear they should go out from the complicated clock-work so frequently stopping. I was, therefore, as it were, driven to invent a lamp, having had such constant opportunities of experiencing what was actually required. It is impossible for this lamp to go out. There is nothing to prevent its burning, the same as it is now, for the whole time that the carbons will last; and the lightkeepers report that it has never gone out, from the time it was started to the present time. It is true that a lightkeeper has, through his own fault, put it out two or three times, simply through mismanagement. I will show you how it was done. The carbon has to be fixed in a kind of vice. Instead of screwing it up tight, he has left it loose, and upon lighting it the carbon has dropped out. The carbon having dropped out, he has simply to ascend and draw these two stops of the other lamp; that one lights, and he can remove this out of the way, and pass another in its place, so that he can again light it up. As their instructions are never to let the carbon burn out within a quarter of an inch, in case of an accident of that sort, they have always got time to light that up again, while they regulate the action of the light below. Again, it

takes ten minutes to change the carbons; but although it takes that time, the light is not out ten minutes, because one lamp is lighted in the upper lens, two lenses being fixed. One lamp is fixed above the other. While the carbon is being consumed in the upper one, the lower one is in its place ready to be lighted. It is simply to lock this top one, then, on drawing the bolts of the lower lamp, the carbons touch, put the upper one out, and light themselves, therefore the light itself is never missed. No mariner can miss the light, because one lamp is never put out except by the lighting of the other one.

Mr. FINDLAY: It is said that the electric light is intended to be put in eight lighthouses in France. Are you aware of this?

Professor HOLMES: It is in France that the magneto-electric light was first shown by me. Since I left France I have improved upon it, and the improved form is the one I use now. The imperfect machine is the one used by the French, and they have admitted to me that it is not fit for lighthouses. M. Reynaud, the director of lighthouses in France, told me himself that he believed he should have to come to me, although I consider myself that a Frenchman has a very great objection to come to an Englishman for anything. He said, "I believe I shall have to come to you at last, for at present I will not put the light up." This light is steady, and theirs is not. The fault found with the machine, as made by me at first, was, that it was not permanent. Where I first obtained permission to put it up in a lighthouse, I saw at once that it was not the machine I required. I discarded it, and I made another that was more durable and permanent in its construction. The machines made by me now, cannot get out of order; whereas the first were continually getting out of order, being constructed more as experimental machines than machines for permanent use. Again, the French leave out a part of the machine which I call the "commutator." This is an apparatus which directs the compound currents of the machine, so that all the currents pass from the machine in one direction; without this, the light is always surrounded by a purpleish flame, which, besides obstructing a considerable amount of the white light that you have observed, gives the rest of it a decided purple tint. I can give you some idea of the difference between my light and the French light by separating the points thus:— You now perceive that the light is no longer white, and if you look at the reflection on this card, you will see a purple shadow where the light ought to be brightest. Moreover, the framework of these first machines was of wood, and therefore totally unfit for lighthouse purposes, where the atmosphere is so subject to change of temperature and humidity; and where, in consequence, the expansion and contraction of the wood might be the cause of serious accidents by bringing the magnets in contact with the wheels, which, in the French machines, revolve at a very high velocity—300 or 400 revolutions per minute. In the machines I make now, every part is of metal, and the revolutions are reduced to 100 per minute. Though the French Company talk about eight lighthouses, they have not yet had them, nor, from what I have heard, do I think it likely they will have, with their present form of machine. An accident to my machine is totally out of the question, and should there be an accident to the lamp, it can only arise through the breaking of a catgut or cord, and as there is merely a pulley to pass it through, any lightkeeper can reeve another line, and that may be done in a few minutes. I may say that during the time it has been at Dungeness, two catguts have been replaced by the lightkeepers, and each of them has been broken by accident. But this does not arise from the wear of the lamp; simply this, that in cleaning this tube, they have pressed upon it, forced it down and broken the catgut. It is a simple apparatus, as there is no complicated clockwork. It is easily managed by any man, after five minutes' instruction. One of the elder brethren of the Trinity House, now present, learned to use it in five minutes, and taught another of the elder brethren in the same time.

The CHAIRMAN: May I ask how long the charge of carbon will last.

Professor HOLMES: In preparing it for use, the length of the lower carbon is six inches, and the upper one a foot. They last three hours in a lighthouse.

The CHAIRMAN: Then they require replenishing every three hours.

Professor HOLMES: Yes. But to do this, as I before explained, the light is not extinguished. The lightkeeper simply locks the lamp that is placed in one lens, and

draws the two bolts, already pointed out, of the lamp in the other lens. This second lamp is now lit. The one just used, in which the carbons are consumed, is drawn back on a small rail, when it passes on to a traverse rail, moving at right angles to the other rail. On this traverse, stands another lamp, with the carbons ready fixed for use. Suppose this standing to the right. The traverse is then moved to the left, till it comes against a stop, when the lamp, with its carbons fixed ready for use, is pushed forward on the first-mentioned rail, and, on coming against its stop, is exactly in focus with its lens. The two lenses are over one another, and the two stages for the lamps are exactly alike, and two lamps are employed for each lens. The used lamp is allowed to stand until it is cool, when the lightkeeper fixes in it, at his leisure, a fresh pair of carbons.

The CHAIRMAN: This last explanation of the electric light has taken us somewhat away from the subject of Mr. Findlay's paper; and though the matter requires a considerable knowledge of optics, it may be that some gentlemen may wish to ask some questions.

Lord LOVAINE: I should like to ask Professor Holmes a question, whether there is any standard as to the power of penetration of the light.

Professor HOLMES: The best standard I can give would be one or two testimonials. One is from Captain Pittock, of the "Frederick William." He left Dover on one occasion in a mist. After he had got seven miles out, it was found that some part of the machinery was broken, a bolt or something of that kind in the engine. They put back into smooth water off Dover to repair this. That delayed them about an hour and a half. They arrived late at Calais with the mail. At Calais, expecting the boat to arrive as usual, they made signal with a coloured light that there was not sufficient water on the bar for them to pass. After this signal had been burning some time, there was sufficient water on the bar, and they altered the signal. They then saw the steamer as they supposed outside the bar, and after waiting some considerable time and finding it did not come in, they sent a boat out to inquire the reason. Just as the boat was going out the "Frederick William" arrived, and ran into Calais. The question immediately was, "Why didn't you come in before?" The answer was, "We have only just arrived." They rejoined, "We saw you outside two hours ago." "No." "What is that light out there, then?" It was the electric light on the South Foreland; yet, through that mist, it was visible in Calais harbour, a distance of at least twenty-two miles, and Captain Pittock made his passage by it all the way across. When the steamer put back to repair, its lights were not visible from Dover through the mist, though the distance was only a mile and a-half. And the captain of the "John Penn" told me that in coming over in a very foggy night they tried to look out for any light they could see, but it was so foggy they could see none. At last he said, "We must take some soundings." On slackening the speed of the vessel, he observed a light which gave a little glimmer through the fog, and he at once saw that it was the electric light. He then took bearings from that, and made his way to Dover without any soundings. This was when the light was at the South Foreland. It is now at Dungeness, and from the alteration I made in the machine, it is more powerful. Again, a pilot named Goldsack, told Admiral Hamilton in the Lantern at the South Foreland, that he had brought a vessel from Beachy Head all the way up Channel without seeing any light but the electric light. He passed Beachy Head without seeing the light there, and he was then twenty miles from the South Foreland light, and he could see that, while he could not see the Beachy Head light which is a very powerful one. He passed Dungeness within a mile or two, and did not see that light, and he passed near enough to see the light at Cape Grisnez in ordinary weather, but could see nothing of it. He saw the electric light all the time, and anchored in the Downs at nine miles distance. Nothing could show more clearly the penetrating power of that light through mists. I may mention that at the illumination last Tuesday, at the Prince of Wales's marriage, it was the only light visible from Primrose-hill. Dr. Frankland went to Primrose-hill to observe the effect of the enormous amount of flame all over London. The whole of London appeared perfectly dark owing to the fog; not one ray reached Primrose-hill. But there was one little red light which he could see; and as the fog cleared off a little, he could perceive quite clearly that it was the electric light on the top of the

Monument, the only light that penetrated the fog on that occasion. On the same occasion, owing to there being less fog in the opposite direction, the light on the Monument was seen near Bromley, in Kent, a distance of about twelve miles, and there it appeared as a brilliant ball of light.

Captain HEATH, R.N.: I observed, when you showed the electric light just now in the central lens, a large number of coloured rays on the surfaces that reflected them. Is the same effect produced with your apparatus?

Professor HOLMES: Your question is a very pertinent one. It is quite true that this lens, which I am just now using, gives off a large amount of coloured rays; this is owing to the lens not being constructed expressly for so small a light. The focus of a perfect apparatus would be a mathematical point. Now, my light, compared with the large lamp previously exhibited in that lens, may be said to be a mathematical point,—not strictly so, but by comparison. Any point of light placed out of focus of a lens will give coloured rays, as the white light, in passing through the prisms or zones constituting the lens, in such a case will be decomposed. In the large oil-lamp all the points of that light are out of focus, and, therefore, all of them give coloured rays; but, as these coloured rays are passing in different directions, with different amounts of divergence, after leaving the lens, they mix again, and recompose white light, or nearly so. At Dungeness I have two lenses, one much better made than the other. In the one worst constructed, there are a large amount of coloured rays, because the light cannot be so placed as to be in focus with all parts of it; hence all those parts to which the light is out of focus give coloured rays; yet, strange as it may seem, at a distance the whole light appears white, and the reason of this may be thus explained: If the light, in this badly constructed lens, be observed at a distance of three or four miles through a telescope, it will be perceived that some of the zones give, say, red rays, and some green: on approaching or receding the colours reverse, but still the amount of green or red entering the eye at any time is about the same in quantity. I take these two colours as convenient for my illustration; but I might say the same of any pair of complementary colours. It is, however, well known that when two complementary colours enter the eye at the same time from what appears to be a point—and such the light may be conceived to be at a distance—the effect on the retina is the same as if the ray were perfectly white. One of these lenses at Dungeness I condemned, and have had a better one made and put in its place, in which these defects do not exist. It was not however condemned on account of the coloured rays, for they would blend as I have explained, but on account of loss of light from divergence, consequent upon its want of proper focus. You will perceive that the coloured rays only emanate from the zones around the centre lens, while the rays from the outer zones or prisms are perfectly white. The reason is, that these outer zones are what are termed prisms of total reflection, while the zones immediately around the centre lens are refractors.

Mr. FINDLAY: There is only one coloured light used in lighthouses, that is the red; all others are totally inapplicable. They are only seen for a mile; what would be the case with your light?

Professor HOLMES: This light being perfectly white shows every colour perfectly. A little while ago the oil-lamp, as you may have perceived, showed the red colour on this map very well, but not the green or blue, so as to distinguish one from the other; for there are not in fact sufficient blue rays or green rays in the oil-lamp to give enough light in these colours; but in this light, as there are all the colours, consequently it may be used for any colour in a lighthouse. I do not suppose there will be the shadow of a difference between the green and the red light in their penetrating power—that is in their brightness. Nor would there be the least difficulty in distinguishing the colour of the light at sea. Every one knows that a green light shown by an oil-lamp at sea is so imperfect, that it is frequently taken for a white one. In this case it is not only not so, but it is so perfectly perceptible that I believe it to be more effective than a red light. The red light here is magnificent, so is the green one; the red light from the oil-lamp is good, the green is bad, because in a lamp of that kind there are so many red rays and so few green. This light, on the contrary, enables you to give all the colours.

The CHAIRMAN: If no gentleman has any further questions to ask, I shall antici-

pate your intentions by expressing our thanks to Mr. Holmes for the way in which he has explained the penetrating power of this beautiful instrument of his. To be able to penetrate that dense fog last Tuesday is enough for every purpose. Nor should we forget Mr. Findlay who is the author of this very clever paper on lighthouses. I may add that he is the author of one of the best books extant on the currents of the ocean, and that he is one of our very best geographers. We return our thanks to him for his excellent paper, and also to Admiral Collinson for his great kindness in reading it.

LECTURE.

Friday, May 1st, 1863.

Colonel SIR THOMAS TROUBRIDGE, Bart., C.B., in the Chair.

VENETIA AND THE QUADRILATERAL.

By Bonamy Price, Esq.

Mr. Chairman and Gentlemen,

I FEEL that an apology is due to such an audience as that which I have now the honour of addressing, from one who ventures to speak to it on a military subject without any professional qualifications for such a task. I must bespeak your kind indulgence towards technical errors, which your practised intelligence will be quick to detect; and, perhaps, my best excuse will be found in stating to you the actual circumstances under which I first directed my attention to the Venetian Quadrilateral. You will then, I trust, perceive that it was no spirit of presumption which tempted me to wander in a region in which I was a stranger. I hope, rather, to succeed in showing you that I was led by a real interest of England to think it the duty of every Englishman who had leisure for the work, to sift a question for which one particular solution was persistently urged upon public opinion.

About two years ago the English press teemed with warm discussions on Venetia. The possession of Venetia by the Austrians was denounced on every side. Its retention was held up as an act not only of robbery but of stupidity. To say that Italy, and therefore Venetia, belonged to the Italians, did not satisfy the angry vehemence of political writers. Doubtless they were disturbed by a secret consciousness that the doctrine that possessions won by conquest, or awarded by treaties, could be reclaimed at pleasure under the name of geographical limits or nationalities, might involve, at some future day, an awkward application to many parts of the broad empire of England. Nor did they exactly desire for Italy a contest of arms with one of the great military states of the world. It was necessary to seek for some other course. The Austrians must be persuaded or shamed out of Ve-

netia. Venetia, they exclaimed, was a province not worth the keeping. The Italians had set their hearts on having it, and how could Austria expect peace if she refused what would never cease to be demanded? Venetia would thus become a hateful encumbrance on Austria, and a heavy drain on her resources. Was not Venetia the bane of Austrian finance? Was not the large army required to guard it against invasion from without, or to extort a reluctant allegiance from a disaffected population, the abyss which swallowed up the increasing deficits of an impoverished treasury? And then the province so blindly and so selfishly held was so useless! Had not Nature provided a ready-made frontier far stronger than any artificial constructions of military engineers? Much wiser would it be to man the long crest of the towering Alps than to imprison weary garrisons at a heavy cost in a hostile country. The remedy, too, was so easy. Were not the Italians in want of land, and the Austrians in want of money? A profitable bargain lay under their hands. Let Austria sell Venetia, was the daily cry; let her take the gold of the Italians and pay her creditors with it. That would be to do a better business than to cling so obstinately to a worthless territory for which she could show no title.

Such language could not fail to awaken reflection in those who held that the existence of Austria was necessary for the security of Europe. A new and powerful nation was springing up on her frontier, and along with it a new distribution of political and military power. On the one side she was urgently pressed to surrender, out of regard for her own interest, a large and valuable portion of her own dominions; on the other, she did what all great states always do—she defended her territory against encroachment. Who was in the right on this great issue? Was Austria perversely adhering to a possession which all the world told her she would do wisely to get quit of, or had Austria some solid reason for so tenaciously refusing to abandon a province that was so much coveted by others?

It was the wish to find an answer to this question which engaged me very unwittingly in a military argument. The most obvious was also the truest reason for the course adopted by Austria. A single glance at Venetia revealed at once the great fortresses of that province. There they stood in all their prominence, strong in a world-wide celebrity, stronger yet in their number, their individual might, and their position. It was immediately plain that the problem ultimately came to this. Was the military value of the Quadrilateral such as to compel Austria, at all hazards, to retain her hold on Venetia? If she abandoned Venetia would she be losing only a province, like Lombardy, of a given extent, or would she be stripping herself of a military defence of supreme importance to her safety? This was the question which I found myself obliged to investigate, and it is some of the results of that investigation which I now venture to submit to your better judgment.

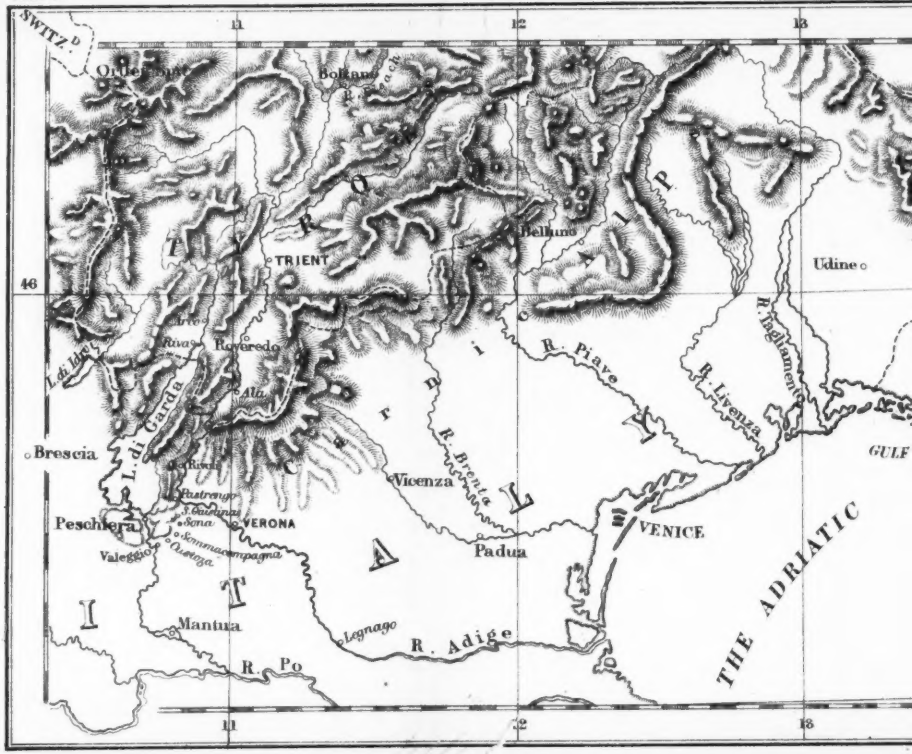
The subject naturally divides itself into two heads: an explanation, first, of the Quadrilateral itself, and then, secondly, of its strategical value.

1. There is scarcely in all Europe a spot so extremely remarkable in

a military point of view as the Venetian Quadrilateral. A few other positions may be yet more invulnerable. It is not so inaccessible as Kronstadt; it is less impregnable than Gibraltar; but for a combination of defensive strength with strategic resources I believe it to be unrivalled. It is not merely a group of four or five fortresses. Flanders can exhibit clusters of fortified towns many times thicker. It is something infinitely greater. Its very name suggests ideas of space and unity that far transcend the limits of a collection of bastions and curtains. It tells of a parallelogram of land, of a stretch of country enclosed within lines of military defence, and of which the forts are only the four corners. The triple barrier of the Netherlands is a battalion in line three-deep; the Quadrilateral is a hollow square, with a large open space within its sides; and as the strength of the regimental line hinges on its firmness at every point, so the resistance of the embattled square is tested, not only by the bristling bayonets that are gathered at its angles, but also by the impenetrability of the sides against which assailing squadrons may be launched. The Quadrilateral is not a group of four detached forts, each shifting for itself; it is rather a system of redoubts of which the peculiar value consists in the links that join them together.

What then are those links? What are the sides of this military parallelogram? What are the distinctive features of country, as well as of engineering art, which have associated with the name of the Quadrilateral a specific idea of its own?

To the eye of the Austrian, standing on the southern verge of his territory, and seeking for a frontier capable of furnishing protection against invasion, the bounty of nature presents a geographical bastion which seems created for accomplishing the same objects as the skilful constructions of a Vauban. The easternmost portion of the great plain of North Italy seems thrown out like a bastion, as if to correct the weakness of a long straight wall of defence. The bastion is composed of four sides of great natural strength. It has for its base, on the north, the chain of the Rhœtic, Noric, and Carnic Alps, commencing at the lofty peak of the Ortler Spitz, and running from west to east to Mont Terglou, directly above Trieste, at the point where the Alps arch into the bow which engirdles the Adriatic. The Ortler, one of the few highest mountains of the Alps, stands at the angle of the bastion, like the highest pinnacle on the top of a cathedral tower. Its situation is critical for the position I am describing. At the Ortler, Austria and Switzerland meet. West of the Ortler, the neutrality of Switzerland, as well as the ancestral courage of its people, protect Austria from an attack directed from the westernmost portion of the Italian plain. At the Ortler again, the western side of the great bastion takes its start, and continues in a nearly straight line down to the junction of the Mincio with the Po. On the other hand at Mont Terglou, the eastern side of the bastion hems in with Alpine ranges the frontier of Italy, down as far as Trieste, and then, taking a bend round the head of the Adriatic, pursues its course till it reaches the angular point of the mouth of the Po below Venice. The great and deep river Po joins the angles, and


SWITZ.D
11
12
13
Orlieux
Bolzano
R. Isco
TRIENT
Belluno
Udine
46
Arco
Riva
Roveredo
L. di Ledro
L. di Garda
Ala
R. Piave
R. Tagliamento
R. Livenza
Brescia
Rivoli
Vicenza
R. Brenta
GULF
Pastrengo
Peschiera
VERONA
Sona
Sommacampagna
Valeggio
Quaderza
Padua
VENICE
THE ADRIATIC
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R. Adige
R. Po
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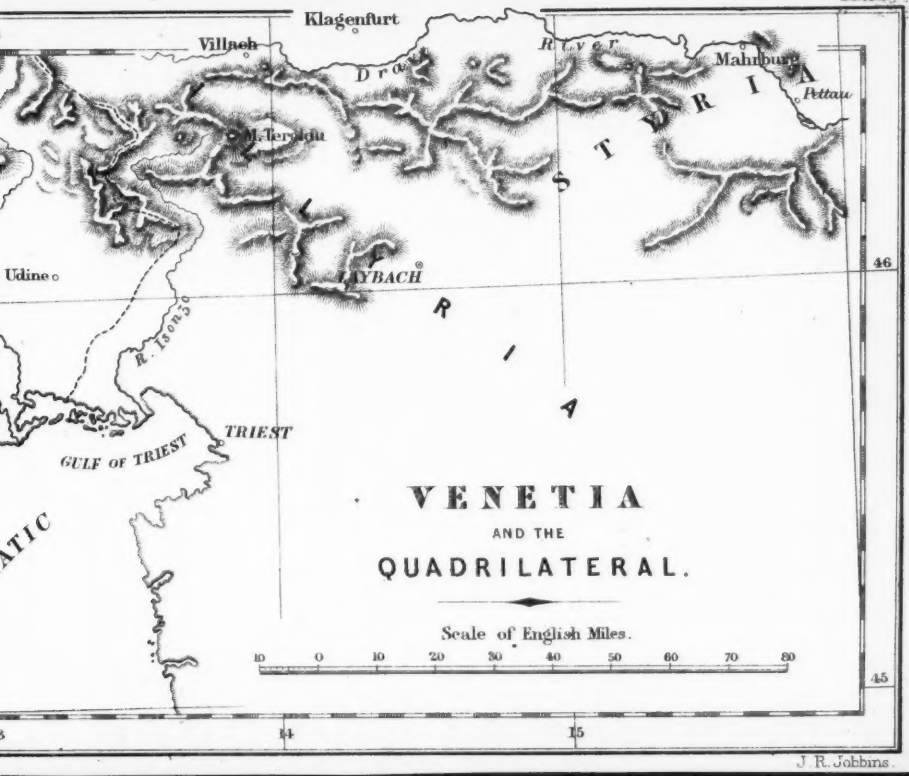
Klagenfurt
Villach
Mahrburg
Pettau
Udine
LAYBACH
R. Isonzo
TRIEST
GULF OF TRIEST
VENETIA
AND THE
QUADRILATERAL.
Scale of English Miles.
10 0 10 20 30 40 50 60 70 80
46
45
14
15

J. R. Jobbins.

completes the fourth side of the bastion, from the Mincio to the Mediterranean.

From this simple description it becomes evident at once, that, by the possession of Venetia, Austria interposes a large tract of strong and defensible country, which must be conquered ere the chain of the Alps can be crossed, and a mortal blow be struck at the heart of her dominions. But this great geographical bastion has one defect: it is too large, it cannot be embraced within the operations of a single army; it cannot be defended by a single force acting on one centre, and directing all its movements to one single end. Too great an extent of line is a notorious weakness for a purely defensive action. But the bounty of nature has again come to the help of Austria; she has anticipated the science of defensive engineers. We all know what a garrison is wont to do when the enemy has effected a breach in the fortress; they intrench the breach, and the assaulting columns mount only to find a new precipice at their feet. Nature has corrected the weakness of the great bastion by forming a narrower one within; she has constructed the true Quadrilateral, capable of being defended by a single army, and composed of posts which can mutually aid each other in one common defence.

The inner bastion is formed by the help of a mountain ridge and a great river. The ridge is the wedge or triangular promontory of the Alps, which carries its base from the Ortler to the corner north of Belluno, and converges to a point at Verona, where the hills sink down into the plain. The river is the Adige, which flows through the bosom of this promontory, then nearly encircles the town of Verona in its course, passes by Legnago, and, turning eastward towards the sea, loses itself in marshes below that fortress. Thus we have the four angles and the four sides of the Quadrilateral. The former side from the Ortler to the mouth of the Mincio, continues unchanged. The northern side is shortened off at the Belluno corner. On the south side we have a third side in the line of the Po, broken off at the marshes where that river approaches closely to the Adige; and we get a completely new side on the east from Belluno to the Po.

And now arises the question—what is the military value of this Quadrilateral? I say this Quadrilateral, because I have not spoken here of the Quadrilateral in its usual sense of the four towns which form a sort of parallelogram with each other; but of the true Quadrilateral formed by the real lines of defence, such as I have tried to describe them. From the Alps, and the regions north of the Adriatic Sea, there can come no attack; for these regions are Austria herself. On the east, a direct assault must have the sea for its basis, a very unsteady one certainly, and one which would have to encounter the shallow lagoons and countless forts of Venice. The civil war now raging in America has shown us how powerful forts are even against iron-clad gun-boats, and there is scarcely room for doubting that the day is not distant when the casing of forts, especially of small forts defending approaches by water, will be an established department of the engineering art.

If the attack on Venice is a main attack, it will require an immense

army; and even to land such an army is an operation of the first magnitude in war. As soon as it reaches the shore, it must lay siege to Venice, or mask it. In either case it would be exposed to attacks from an Austrian army marching down from Hungary and Carniola, as well as from Verona; and the last siege of Venice has shown how arduous and long such a task would be: in other words, the fortress will have done its work. It may not have been impregnable, what fortress is? but it will have cost much time and loss to the enemy, and will have enabled the Austrians to concentrate and move forward their resources. Venice, till its capture, will have sheltered the Quadrilateral. A main attack, therefore, from the Adriatic, is hardly possible. A subordinate attack, such as was threatened by the French in 1859, is more probable; but Italy alone can scarcely be considered equal to carrying on a main attack by land on Venetia, and a vigorous one by sea against Venice at the same time. Two nations would be needed for such a double invasion—two armies required to take the field; and it would be no small praise for the great Italian bastion to give the means of opposing an effective, if not insuperable, resistance to two enemies of Austria invading at the same time.

But may not the invader advance from the south? What reply would the southern side of the Quadrilateral make to such a challenge? This, surely, that if the assault strikes straight from the south, and is unsupported on the east or west, let it come on if it dare. First of all, from what quarter are the assailing columns to advance? If from Ferrara, they stumble against no mean obstacle, the large and deep river Po, a river, too, whose passage is capable of being stoutly defended by the Austrians. Once across the stream, two lines of operation are open to them. They may march straight on towards the north, so as to turn the fortress of Legnago, and then burst upon the Quadrilateral in its rear, on its eastern side between Legnago and Verona. In that case, a second great river lies before them, the strong and deep-flowing Adige. Before they reach it, the battalions and their supplies must wade through a swampy region, beset with Italian malaria and pestilential fevers. None know better than you that it is not the rifle or the sabre which commits the deadliest havoc on the numbers of a great army. The toils and sickness of a campaign have a far greater desolating power. The passage of the Adige, as of the Po, must now be fought for; that done, the left flank of the army becomes exposed to sallies from Legnago, Mantua, and Verona, whilst its unhappy right may tremble at the prospect of succours swarming down over the north-eastern Alps. A defeat in such a position with two great rivers in the rear, might easily prove destruction; no prudent general will lightly expose his army to such hazards.

A main Italian invasion, therefore, will not probably advance from Ferrara; the storm is far more likely to burst from the west, where Italy possesses more available resources and a broader territory than the district which lies on the east between the Appenines and the Lower Po. The eagles of France may march in line with the standards of Italy. The joint attack of the two Gauls is what the Austrian must ever be prepared to meet. There lies the real danger, the true

problem. I do not say that France and Italy will swear an eternal league for the downfall of Austria; that is a question of politics, which would be out of place in this room. But I do say, that in the eddying waters of national movements, a French and Italian alliance would only be a repetition of what has occurred many times in the past, and that it constitutes a danger so formidable and so probable, that Austria can never be considered safe, if unprepared to resist it. The chain is no stronger than its weakest link; the test of the value of a system of defence is the maximum of danger which at any time may be brought against it. When, then, the united Gauls are gathered, or even the single-handed levies of Italy are mustered alone, what will be the line of their forward march? Will they direct their steps against the southern wall of the Quadrilateral between Mantua and Legnago? Consider the invader's position. On his immediate left he has Mantua, an extremely strong fortress, manned by a powerful garrison, buried amidst lakes, inundations, and swamps, unapproachable for the most part except by five narrow causeways, which are carried through water on both sides under the guns of the batteries, and are protected by very strong outlying works at the points where they join the main land. Such a place, if it can be taken at all by siege, will avenge its fall by an enormous expenditure of time, men, and resources. Below Mantua the swamps still continue, and a very little way on, the Adige, with Legnago, hems the advancing army on its right flank. No doubt the enemy may blockade Mantua, as Napoleon did, as Charles-Albert tried to do; and he can mask Legnago or take it, for it is only a small fortress, scarcely more that a *tête-de-pont*. But here again would be loss of time, and consumption of force; and still there would remain in his front Verona, a fortress of the first magnitude, or rather an assemblage of forts with a large entrenched camp inclosed within them, covering a whole army within its lines, and possessing free communications with the resources of the whole empire. Under such conditions, we cannot but conclude that a main direct attack on the southern side of the Quadrilateral is in the highest degree hazardous and improbable.

Now, let us change front, and face towards the west. In the west the real danger looms; in the west are the masses and the resources of the enemy. From the west the tide of war will come rolling on in the future as it did in the past. The active soldiers of France have climbed the Cenis; the serried divisions of united Italy have gathered in the western plain; Genoa and Alessandria give them a basis of operations. The Austrian general keeps watch in the central citadel of Verona,—what fears and what hopes are his? No uneasiness troubles him for his extreme right. The Ortler frowns over the Stelvio pass, which raises its road to a height of 8,000 feet above the level of the sea. A projecting spur from its side covers the upper Mincio, and forms an insuperable barrier almost to the head of the waters of Garda. The broad and beautiful surface of the lake—and who does not now think of Sermione and Catullus?—carries on the line of defence to the point where Peschiera defends the outlet of the now wider Mincio from the lake. Ships can doubtless traverse the rolling

waves—waves which, as I can myself bear witness, enable the Garda to be addressed now, as it was by Virgil,

Fluctibus et fremitu assurgens, Benace, marino.

The French in 1859 are said to have intended to launch gun-boats on these lovely waters; but what would they avail against a single "Monitor," prepared before hand, and armed with the artillery which modern science has invented? From the Ortler, then, down to Peschiera the general's eye sweeps over his line undisturbed. At Peschiera he sees fort rise on fort, hills bristling with cannon, and a many-sided group of ramparts manned by a strong garrison. He knows that weaknesses revealed by past wars have been corrected, and that commanding heights, formerly bare, are now crowned with batteries. He is hopeful still; and we will not yet ruffle his confiding calm. From Peschiera his glance flies across to the lower Mincio. Half-way before it rests on the bastions of Mantua, it passes on contented over the broadening banks of the expanding river. Those wide waters continue some ten miles further on below Mantua, amidst marshes and rice grounds and a singularly difficult country, till the Mincio is lost in the Po. An enemy is little likely to engage himself deeply in such a country, whilst Mantua threatens his flank or rear—Mantua which for many a weary month baffled the might and arrested the march of the great Napoleon.

But, as it returns backwards, the survey of the Austrian general is compelled to detect the weak spot in his outer wall. For the first half of the distance between Peschiera and Mantua, a gap of ten or twelve miles broad lays bare an opening for the enemy. The Mincio here presents no formidable obstacle to his advance. To defend himself against the dangers of this approach, the Austrians must rely on Mantua and Peschiera, and the still stronger reserve of Verona in their rear. We are now, therefore, enabled to understand the peculiar character of this defensive position against an assault from the west. The extreme right of the Austrian army cannot be easily turned—not at least till after Peschiera has been taken or masked. The Alps and the Lake of Garda bar all access above Peschiera on the west. But the Austrian general has something infinitely stronger to rely upon than a single river, weak in parts, and though it be flanked by two strong fortresses—one at each end. He possesses a line of still greater value—the line of the Adige, which is so situated as to complete the first in a manner probably unequalled in the world. The Adige lies so close to the Mincio as to form one single system of defence along with it: and yet it is far enough apart to present an absolutely new obstacle, if the first is pierced through. A beaten garrison can fall back on the second line in a couple of marches, and add its strength to that line. The same short distance only separates the reserves, and the resources of the second line, whether it be necessary to succour any part of the first line which is attacked, or to assail an enemy who has established himself upon it. Before an enemy can advance in safety, Peschiera must be first stormed or blockaded, and help is close at hand for Peschiera. There are Mantua

and Verona, and the resources of Austria converging on Verona. The Austrian general has the same command over the two lines simultaneously, as a commander has over the wings and reserves of his army in a great battle—he can strengthen or draw from each at pleasure. The two lines form one whole, precisely as the several corps of a single army. An enemy who has mastered the Mincio, whatever he may have done with Mantua, has still greater difficulties in his front; for Verona with the Adige is much stronger than the weak parts of the Mincio, or than Peschiera. It is this inter-community of aid which has knit the four fortresses into a single whole, and which paints them to the eye of a tactician, as four corps d'armée on the same field.

There is however one peculiarity in the ground which requires notice, for it constitutes a weakness which has often given the Austrians trouble. The upper Adige, in its downward course, is unable at Roveredo to maintain its southward direction. It meets the high ground of the projecting promontory, and is compelled to turn aside into a narrow valley on the west of the hills. It bulges out, so to say, till rounding back at Verona, it forms the second line of defence, and from that point it is in a certain sense parallel to that of the Mincio. It is pushed out of its natural course, and is thereby above Verona brought into close neighbourhood to the Mincio. In a military sense, this is a disadvantage. By forcing Peschiera, the enemy has almost cleared the second line at the same leap. There is scarcely intervening room for new combinations. The enemy threatens the communications of the Quadrilateral with Austria, he may soon be nearer the Alps than the Austrians themselves; and if Peschiera has fallen, he may thread his way up the narrow glen, and even climb the low pass of the Brenner. One obstacle alone bars his path, but that obstacle is strong enough to roll back for awhile the invading flood. That obstacle is Verona, and the configuration of the ground near it.

To describe Verona as one of the angles of the Quadrilateral would suggest an erroneous idea of its true nature. It is more conformable to its actual position to say that Verona is the heart and citadel of the whole defensive system of Venetia, and that Peschiera, Mantua, Legnago, and Venice form a circle of outlying defences, guarding the approaches to Verona in the centre. The forces of the monarchy communicate with Verona, in the first place by the main road, which, after crossing the Brenner from Innspruck, runs down the defile under the heights of Rivoli, between the promontory and the Lake to Verona. The railway is carried along all the distance, except between Innspruck and Botzen, and measures, I hear, are in contemplation for linking this space with lines of iron. A second mountainous road winds round eastward, by the Val Sugana, to Verona: this road communicates with Vicenza. A third, and the most direct road of all, is either in construction or is projected, along the top of the promontory straight to Roveredo. Moreover Verona has got other channels by which she can derive help from the interior. A railway proceeds from Marburg eastwards, and can bring along it the strength of Hungary to Klagenfurt. From Klagenfurt three roads branch off to carry supplies to Verona; one descends by the Valley of the Isonzo, and reaches the eastern con-

fine of the Venetian plain. The second follows the course of the Tagliamento to Udine. Both converge on Vicenza, and so on to Verona. A third proceeds in a due westerly course from Klagenfurt up the valley of the Drave, mounts a high intervening plateau, and finally, reaches the high valley of the Eisach and, ultimately, joins the line of the Adige.

These are the arteries which supply military life and strength to the Quadrilateral, and to cover these is a matter of vital necessity for Austria. Verona lies precisely at the extreme southern end of the promontory, and is built partly on its east hills, and partly in the plain. This double position of hill and flat land, combined with a large, rapid, and very winding river, furnish the precise elements needed for a great fortification. Space is obtained for a great entrenched camp and for the accumulation of military stores, whilst the hills and the river furnish singular facilities for defence. One curious geographical feature characterizes Verona. On its western side the town is surrounded by a rideau, or semi-circular cliff, some dozen feet high, enclosing a large space of low ground, on which the town itself is built. At this spot the river had opened out at some geological period into a broad sheet of water, bounded on one side by the last spurs of the Alps, on the other by an ordinary natural bank. The water afterwards retired, the Adige withdrew into its present narrow bed, leaving behind a kind of semicircular, flat amphitheatre, below the general level of the Italian plain. By this operation the bank rose up into a perpendicular wall like the rim of a billiard-table, sweeping round the flat ground which had been the ancient bed of the river. It forms a very considerable impediment to troops sallying from Verona; but on the other hand it is admirably fitted to serve as an entrenched camp, thus powerfully contributing to carry out the main idea of Verona to be a protected station for an army, yet more than a purely defensive fortress. The hills, which on the north rise abruptly out of the town till they reach the summit of the promontory, are covered with numerous forts. On the south-east the windings of the river render access almost impossible; so that the points from which Verona can be assailed with advantage are few. Many forts have been recently constructed to guard the approaches from the west and south. Taken as a whole, Verona may be regarded as a grand central *tête-de-pont*, defending the arterial roads which lead to the interior of Austria, capable of furnishing efficient shelter to a beaten army till it has had time to recruit itself, and affording the most excellent means of directing prompt and effectual aid to any of its outer strongholds. Whilst Verona remains unsubdued, an advance against Austria is impossible; for even the possession of the defile above Verona would be useful only against that fortress. Innspruck would be unassailable so long as the garrison of Verona occupied the rear.

But there is a heel of Achilles in everything human, and I have shown that for the Quadrilateral the vulnerable part is the permanent gap between Peschiera and the widening waters of the Mincio. Through that gap most of the invaders of Venetia have passed. The natural course of the enemy is to reduce Peschiera, and then, masking

Mantua, to push on towards Verona. For the siege of Peschiera, the country offers a great advantage to besiegers who have a decided superiority in the field. A range of heights, commencing near Peschiera, extends in a north-easterly direction, and presents a bluff steep front on the side of Verona. This is a capital defence for an army covering the siege, for it is not easy of assault on the Veronese side. An enemy strong in the field finds no great difficulty in occupying these ridges from the western side, whilst on the east it requires a very powerful effort to force them. The Italians in 1848, under Charles Albert, conquered these heights, and the results were, first, that they were enabled to blockade, and ultimately to take Peschiera; and then, secondly, they pushed their left on to the valley of the Upper Adige, seized the plateau of Rivoli, and made a direct attack on the villages close to the very gates of Verona. Similarly, in 1859, the French regarded Peschiera as the key that would unlock the road to Verona, and had made great preparations for its siege.

By means of the lake, and its communications by land, Peschiera is an obstacle which no enemy can overlook. He dares not leave it in his rear unchecked. On the other hand the loss of Peschiera exposes the right flank of the Austrians, and threatens at once their communications in the valley of the Upper Adige. To guard against this peril, a new and strong fort has been built at Pastrengo, so that the road to Austria now enjoys a security which it never had before.

But still in any case, even after the fall of Peschiera, Verona is able for a most valuable space of time, to guard the second line of the Adige, and the passes over the Alps into Austria.

In judging the military value of the Quadrilateral, it must be understood that it is not a system of four isolated forts, each taking its own separate chance of resistance or capture, nor even of four forts linked together, as I have already pointed out, in mutual support. It is something greater still. The army which manœuvres within its four sides must never be lost sight of. The force which guards the gap is not merely the garrisons of Mantua and Peschiera, nor even in addition the garrison of Verona; it is an Austrian army, more or less large, operating on a field of battle, which is strengthened by powerful redoubts on its flanks and rear. The strength of a small army for defence is mightily increased by these rallying points, even though not a single soldier from their garrisons should be added to its ranks. The resistance therefore which is presented by the Quadrilateral to an enemy is not to be measured solely by the strength of its lines and its forts, but also by the vastly increased impediment opposed to his operations by the action of a movable column freely manœuvring within its area. The military importance of such a force is immense, for it fulfils the great principle of strategy, that no defensive is strong which does not contain within itself the means for a powerful offensive. It is the glory of the Quadrilateral that it combines these two great qualities in a degree unequalled by any other system of fortifications in Europe.

Such, in general terms, is the Venetian Quadrilateral. The service it can render was conspicuously illustrated by the brilliant campaign of

1848. The situation of Austria was intensely critical; revolution raged in the capital; the Emperor had been driven off to Innspruck. Civil war tore asunder the provinces, and the vigour of the civil and military government was shattered; Lombardy and Venetia were in revolt; supplies and reinforcements were scarcely obtainable; the army, a bare fragment, was isolated amidst a raging sea of insurrection, and of that little band whole regiments, composed of Italians, were disaffected and deserting. Never was danger more imminent. The loss of the Italian provinces would have destroyed the empire. But there was the Quadrilateral, and there was a veteran of 82, and the strength of the one and the energy and genius of the other, saved the monarchy from ruin.

The Italian campaign of 1848 presents some striking points of resemblance to some of the earlier ones of our great Duke in the Peninsula. There is the same sagacious caution and the same prompt audacity, the same necessity not to lose a single man needlessly, the same prudent retreating before an overwhelming superiority in the enemy, the same quickness and dash in resuming the offensive, the same retiring behind strongholds which no assaults could force, and the same rapid and telling blows on a bewildered and astonished foe. The ramparts of Verona recall to mind the invincible lines of Torres Vedras, and Marshal Radetsky's counter-march on Vicenza reflects the daring advance on Talavera. Had Torres Vedras been forced, Wellington's soldiers must have taken refuge on the sea, as Moore's did at Corunna; if the Quadrilateral had not held out, Venetia would have been lost and the Alps would not have saved Austria from dissolution.

Charles Albert took the field at the beginning of April, and the work of the campaign was begun by a successful surprise conducted by the illustrious chief, then Colonel Benedek, who had succeeded to Radetsky's command at Verona.

Let me be allowed at the mention of that name, to pay a tribute of gratitude for the friendship with which he has honoured me. Who that has known him will not recall to mind the spare and active frame, the eagle glance, the fiery energy, the quick and sagacious daring of the great Feldzeugmeister; and who can wonder that such a man should have won the hearts and wielded the devotion of every soldier in the great army of Austria? To be commanded by Benedek is, to the feeling of the Austrian legions, but a sure pledge of victory.

Radetsky retired from Milan, which was but an open town, and slowly retreated on Verona. The Sardinian king advanced through the gap below Peschiera, and soon crossed the Mincio. Mantua and Peschiera were thus at once isolated, for the superiority of the enemy's force gave him entire command of the open country; and so sudden had been the revolution and the war, that both places were most inadequately provisioned. But Mantua was safe. The outspread waters of the sluggish Mincio, made still larger by inundations, could not be waded by artillery. Marshes malaria, and an active garrison did their work. Mantua was never besieged in earnest in this war, and probably never will be again. But it was otherwise with Peschiera. The ridges which run down from the Tyrolese mountains, between the

right bank of the valley of the Adige and the Lake of Garda—the ridges of Sona and Somma-campagna, which I have alluded to already—reach close into Peschiera. Charles Albert seized on Somma-campagna and thereby gained two great advantages; he occupied heights fronting Verona, which shut out aid from Peschiera, whilst pushing forward his left, he mastered Pastrengo (there was no fort there at that time), and thus threatened the communications of Verona with Innspruck.

Radetsky lay within his ramparts, waiting for the scanty reinforcements which Nugent was collecting beyond the Isonzo. Charles Albert, in order to anticipate them, resolved to test the strength of the defences of Verona. They were feeble then compared with what they are now. He assailed the villages of San Massimo and Santa Lucia on the edge of the Rideau, with great spirit, but though he had 50,000 men against 16,000, he failed. The present Emperor of Austria, then the Archduke Francis Joseph, shared in the honours of that resistance. The relief achieved its march from the north-east to Verona, whilst Charles Albert clung to the heights of Somma-campagna, and awaited the reduction of Peschiera. Thus far the Quadrilateral did its work successfully. Though Venice was lost to the revolution, and the country on all sides, in the Tyrol behind as well as the plain in front, was in revolt, and the fortresses incomplete and ill-provisioned, a very superior army had been brought to a stand-still by a small one, and time had been gained for the arrival of succours. To effect this end is the one object of every fortress. But Marshal Radetsky found, that unlike Wellington, he had no British fleet in his rear, to supply him with all that his army wanted. The sterile valleys of the Tyrol at the best had nothing to spare, the little they produced had been already consumed. Massena retreated from Lisbon because his army could find nothing to eat; here it it was the beleagured force that was set in motion by hunger. Most of all, the Marshal felt that an attempt was to be made to relieve Peschiera. A direct attack on the covering force, now entrenched on Somma-campagna, might be doubtful—certainly would be bloody; a move towards Mantua would take the enemy in the rear, and draw him from his position. So a new step in the war now commenced. Radetsky availed himself of the advantages of the Quadrilateral, he marched to Mantua. By so doing he exposed his flank to the enemy, but the veteran was at any time ready to wheel round and give battle. In such a contingency, Verona would have covered his right, Mantua his left, and a very difficult country his front. The first consequence of the army's arrival in Mantua was the rout of the Tuscan division of the investing force. The next was, that the Marshal quickly brought down Charles Albert from the crest of Somma-campagna. The third movement did not equally succeed; he could not force back the King at Goito with 12,000 against 20,000 men. Upon this Peschiera, hopeless of succour and sorely pressed for provisions, surrendered. But now see the marvellous energy and undaunted courage of the old soldier. On the very night after he had heard of the capitulation of Peschiera, and what was still worse, of the overthrow of the Imperial Government at Vienna,

the daring Commander countermarched his army from west to east. He turns his back on a superior foe, and crossing the Adige by the bridge at Legnago, steps beyond the lines of the Quadrilateral, and suddenly appears before Vicenza, and wrests that city from its Italian troops and insurgent population. The conception of this brilliant feat of arms has been ascribed to the genius of Marshal Hess, and those who have enjoyed the personal acquaintance of the Marshal, may easily believe this distinction to be his; but, however that may be, the glory and the courage of giving the order for its successful execution belong of right to the gallant old man of 82.

A pause of six weeks' inaction followed, and then the final scene of the drama within the Quadrilateral opens. Charles Albert had invested Verona, with what exact object is not sufficiently apparent. Radetsky resolved to move out and drive off his foe in earnest. He had regained Rivoli, and swept the Italians from the Adige. He was eager to recover the heights which range from Custoza to the Mincio, and domineer over the flat ground far away to Mantua. That done, he changed his front towards the south, and placed his army *à cheval* on the Mincio. By this change, he gave his enemy, who was entrenched close by at Villafranca, a chance of assailing his flank and rear; an action followed; a wearied brigade gave way, and the Italian King again became master of the dominant ridge. But the indefatigable Chief was swift to repair the disaster. He resolved that the following day, the 25th of July, should witness the expulsion of the invader and the salvation of the empire; were it necessary, he himself in person would lead the grenadiers to the assault. Again the peculiarities of the Quadrilateral became conspicuous. On the preceding day, the 24th, the Governor of Verona had descried the battle from its lofty tower, and guided by the success of the enemy, had directed on Somma-campagna, now won by the Italians, reinforcements which had been ordered to another quarter. These fresh troops stormed the ridge under the fierce sun of an Italian summer, and the Austrians, at last, stood triumphant on the fatal hill. The campaign was decided; the Piedmontese retreated from Venetia, Peschiera was restored under an armistice, and the old Marshal and the Quadrilateral saved one of the great States of Europe from ruin.

We have now seen the characteristic features of the Quadrilateral, and the services it can perform. The great campaign of Radetsky has shown that it is not a mere collection of forts, nor even a last citadel to stay the advance of ruin. It is also a vast battle-field, in which the fortresses play the part of gigantic redoubts and entrenchments. It is a huge fighting-ground on which an army can take up a position for attack or defence at pleasure, with rivers to protect its flanks and rear, and mighty ramparts for its Hougoumonts and its Haye Saintes.

2. I am now brought to the second great division of my subject. The Quadrilateral is strong, very strong, but ought it on that account to be Austrian? It lies geographically on Italian ground. Is it a Gibraltar of disputable title? Is it a trophy of conquest, or is it, under some higher law, a necessary and permanent portion of Austrian territory? For

the statesman this is a question of supreme importance. The peace of Europe demands that it shall receive a solution, a solution that shall be recognised as founded on abiding principles, and that shall ultimately command the acquiescence of the contending disputants. If Venetia is not a vital necessity for Austria, in the name of humanity and tranquillity let it be ceded to the Italians; there never is any loss of dignity in doing what is right. But if Austria cannot part with Venetia without risking her existence, let Italy cease to regard it as Italian ground, and put an end to desires which shall have been proved to be illegitimate. The law of self-defence is supreme in human life.

The question is a great one, but the answer is not difficult. Venetia is to Austria what the Channel is to England, the one condition of existence. Let an Englishman think what he would feel if asked to give a French fleet free access at all times to the English shores, and then he will understand what are the feelings of an Austrian, when asked to renounce Venetia and to trust to the lofty slopes of the Alps. The Quadrilateral is not a Sebastopol, threatening invasion and conquest to a neighbouring state; nor is it a Malta protecting a great and legitimate interest from harm. It is rather the shield which averts the one fatal stab from the heart; it is the British fleet keeping guard on English homes. But for Trafalgar, London might have fallen, though England might have survived; without the Quadrilateral, Vienna lies at the mercy of a French or Italian invasion. If this is so, all dispute as to the title to Venetia is at an end. It must be Austrian if Austria is not to become a power of the second order.

Is this view then correct? Can it be established by solid reasoning? In the first place, without Venetia, Austria has no frontier on the south. The Alps are no frontier, no long mountain range can be one. A mountainous country is hard to reduce to subjection, but it is easily run through by a strong invader. Its chain of heights, however lofty, is little better than a screen to hide the operations of an enemy. General Clausewitz, the highest strategical authority that can be quoted, lays down that an attack which is resolute and strong enough for fighting a decisive battle, will reach its adversary in the mountains, and will be carried on with advantage there. His enemy is compelled to make too wide a dispersion of his troops. He does not know by what pass the invader will approach, and he is liable to be turned by those passes which he does not occupy. Colonel McDougall repeats the same doctrine. He quotes the Duke de Rohan, who defended the Valteline against the Spanish and Austrian armies. Although the flanks of the army, says the Duke, were thought to be securely protected by the mountains as by so many fortresses, it was found to be exposed on all sides, and one opening was no sooner closed than two more were discovered; so that several armies in place of one would be required to defend this country.

History confirms the theory. No invader was ever stopped by the Alps. Hannibal had to contend against one of the most perfect and most stubborn military organizations that the world ever saw, yet he passed the Pyrenees without difficulty. Scipio tried to intercept him

in the valley of the Rhone, but having missed his foe, did he try to defend the Alps? He embarked his army, and sailed round to meet Hannibal as he emerged from the mountains. Buonaparte carried an entire army over the perpetual snows of the St. Bernard, in regions without a road. Suwarrow forced his way into Switzerland, although the broken Devil's Bridge left nothing but yawning precipices before him. Soult burst through the Pyrenees with an army of recruits, and well nigh shivered in pieces the warriors of whom Wellington said that they could go anywhere and do anything. He was pulled up only within 6 hours' march of Pampeluna. A single fortress in Flanders used to cost Marlborough a campaign. What great army ever halted because it could not get through a mountain-range? Mantua kept Buonaparte a whole year in Italy. After Mantua had fallen, twenty days sufficed for the soldiers of France to force two great passes of the Alps, and for their advanced guard to encamp within sight of the steeples of Vienna. Low and confined heights can add great strength to a defensive, but a long mountain-range, or a wide hilly country, can never be closed up. The reason is plain. It is impossible to guard every pass, and if every pass were guarded, the assailant could always mass his troops against isolated posts and force his way through before the invaders could concentrate. This was the great danger to which Wellington was exposed at Sorauren. On a level piece of ground, the plan of the enemy's advance can be seen, and concentration is easy; in mountainous regions it is a very slow and a very difficult operation. It was no slight effort to arrest Ney at Quatre-Bras; what would it have been, if the various divisions of the English army had had fifty miles to march down one valley and fifty miles up another, before they could have collected their strength in a single army? An army posted at Verona can mass itself in many quarters, and can strike over a long range The same army scattered over the valleys of the Tyrol and Carinthia, would be weak everywhere, and would leave half the passes unguarded.

But, secondly, the loss of Venetia would do a mischief infinitely greater than strip Austria of a southern frontier; there is a much mightier and more decisive consideration still involved in the question. Take away Venetia, and you lay bare the heart of Austria—there is nothing to stop the invader between North Italy and the plain of Vienna. Vienna would then be as defenceless as London would be if the French had crossed the Channel, and precisely for the one reason which has been so often urged for the cession of Venetia. The intervening country is mountainous. There is not a single defensible position by which a great army could be stopped between the waters of Italy and the valley of the Danube. That was proved in 1797, in the direct attack made on Austria from Italy.

The Tagliamento would prove no obstacle, it may be forced without a bridge: the Isonzo is weaker still. At Laybach, the enemy would have the choice of two roads, one though Styria, the other through Carinthia. Some positions and lines might be found in Styria, but generally the country is too mountainous, and the invader would take the more direct line through Carniola. It is a great principle of de-

fensive strategy so to place strong places as to divide the field of the enemy's attack; but all this region affords no means for accomplishing this object. A flanking fort might be made at Villach, but the situation does not admit of more than a place of the second order. Pettau is a much stronger point, but it is too far off; it could not arrest the enemy's march by the direct line. The Save and the Drave are too shallow. In the plain of Vienna, under the walls of the capital, would the invader be pulled up for the first time, and the first battle might decide the fate of the war, and possibly of the monarchy itself. And then see the disadvantages of such a defence. The advance of the enemy would at once compromise all the Tyrol, Dalmatia, Istria; they would be at his mercy. Trieste and the sea would be lost, the naval establishments of the nation sacrificed. If the Quadrilateral ceased to be Austrian, the enemy would commence his invasion with advantages which it would now cost him, one, probably more, campaigns to acquire. Modern wars are short, because they are expensive. A hard struggle for the Quadrilateral would probably end any war. The French halted before Venetia in 1859. Various reasons were found for peace; but would peace have been made then, if there had been no Austrian guns at Peschiera and Verona? Can the Italians, can Europe, ever expect that the Austrians would voluntarily reduce themselves to helplessness by the loss of such a shield? Where is the nation in the world which would make such a sacrifice to any other argument than that of force?

And now we can face the objection so often urged in the English press—the ruinous cost of the force which guards Venetia—as if forsooth the soldiers who man its ramparts were only so many policemen to watch the Venetians. Those garrisons and that army are the necessary military defenders of the empire, and nowhere could they be so few, so cheap, and so effective as in the Quadrilateral. The Quadrilateral is perhaps the most magnificent economy in Europe; for it makes every soldier do the work of three. Thrice the army which now occupies Venetia would not defend so efficiently, and at such little cost, the southern frontier of Austria. If the Quadrilateral were to pass into other hands, more regiments would be required, more money spent in protecting the Alps and the territory in their rear, and the work would not be half done after all. As it is, the battalions in Venetia do keep back invasion. The whole army of Austria, distributed over these mountainous countries, could not bar the road to Vienna against a resolute Gallo-Italian army.

But not in Italy alone does the Quadrilateral act the sentinel for Austria, it is felt also across the Alps in the old line of invasion along the valley of the Danube. French columns never could march comfortably with the Venetian garrisons on their flank. If a strong Austrian force had been posted in the Italian Tyrol in 1805 and 1809, Napoleon's marches on Vienna would have been neither so easy nor so triumphant. The fear of a vigorous attack from over the mountains which skirted his right flank would have made him pause, and might possibly have defeated his object altogether. It is a new praise, and no slight one, for the Quadrilateral, that it menaces with very serious

peril a French invasion, as it emerges from the Black Forest on its march to Vienna.

But the merits of Venetia are not yet exhausted. There is a third service which it renders not only to Austria but to Germany, of which it is hard to exaggerate the value. In these latter days of the world, to be cut off from the sea is to be shut out from the most stirring interests of modern life, to be dependent on foreigners for the main element of national greatness, to lose the most active stimulants to progress, to be placed at an enormous disadvantage in all the relations of commerce, and to be shorn of the best hopes of an advancing civilization. How many years will the Adriatic be open to Germany if the great Quadrilateral, with its central army, shall have become Italian? The Alps sweep round the head of the Adriatic with a bending curve, and carry down their ridges along its eastern margin. If Venetia is claimed for Italy in the name of the sonorous principles of nationalities and geographical limits, why may not the same titles be pleaded with equal cogency for Illyria and Dalmatia? Why should Austria possess sailors, when Italian blood and nature's mountains have decreed that they shall have none? When Venetia is obtained, Italy will be at no loss for an answer to this question; but whilst Venice shelters a protecting fleet, and Austrian legions are ready to sally forth from Verona, some better answer than general theories will be required to dispel the great danger of a large force in the invader's rear. The Italian fleet may easily outnumber the Austrian, but Ancona will pause before it throws expeditions on the Dalmatian strand, so long as Venetia has her railways and her transports ready to cut off the advancing foe. This is no merely Austrian feeling; for Trieste belongs to all Germany: so profoundly felt is the need of a German outlet into the middle sea.

But I am often met with the retort, all this is merely speculative sophistry: Austria obtained Venetia but a few years ago; she got on till then excellently well without it. How can it be pretended that the territory of the old Doges is indispensable for her safety or her power?

Those who argue thus forget that they live in a world where change never ceases: and that to take no account of new combinations is to become a Rip Van Winkle amidst a generation that lives under new conditions. The very strength of the Italian demand for Venetia lies in the altered state of Italy. We are a great people, say the Italians, and all Italy belongs to us of right, because we are a great people. But the reply is irresistible. In bygone ages you were only an aggregate of detached fragments, each belonging to a petty ruler. You were insignificant for attack, but now you reckon twenty-two millions of population. You are a mighty force, and you compel your neighbours to think about their safety. This is the tenure on which Venetia is now held. Before the wars of the great Revolution, the very smallness and independence of Venetia constituted the safeguards of Austria. Lombardy, an ancient Austrian possession, was interposed between Venetia and Sardinia, which was itself of no account as a possible invader of Austria. But Italy

is becoming a great state, she will wield the power of a great state and will inevitably feel the pulsations of a great ambition. No blame to her for this, but equally no blame to her self-defending neighbours for whom this expansion of Italy's greatness creates new dangers. A great power must be willing to take the good and the evil of her strength. She must be content to be encircled by her neighbours with a strong frontier. Could old Venice have marched legions over the Alps? Could she have mustered an army that could have forced its way to Leoben or Vienna? Was the union of all modern Italy in attack on Austria a possible event before the 19th century?

The objection has no weight. Austria has no option. If she cedes Venetia, she bares her heart to the smiters; she will live on the sufferance of France and Italy, and the consideration of Europe. The attack which heretofore has been pointed down the Danube will wheel over Mont Cenis to reappear over the ridges at the head of the Adriatic; and then it would challenge Austria to do battle once for all, in the plain of Vienna, if not for existence, at any rate for her capital, and for all the great moral and material stake therein involved. Is it reasonable to expect that a European power of the first order will ever submit to such a hazard? Is it possible?